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# AERONAUTICAL ENGINEERING

A SPECIAL BIBLIOGRAPHY  
WITH INDEXES  
Supplement 75

OCTOBER 1976

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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# AERONAUTICAL ENGINEERING

## A Special Bibliography

### Supplement 75

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in September 1976 in

- *Scientific and Technical Aerospace Reports (STAR)*
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OCTOBER 1976

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# INTRODUCTION

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This supplement to *Aeronautical Engineering—A Special Bibliography* (NASA SP-7037) lists 300 reports, journal articles, and other documents originally announced in September 1976 in *Scientific and Technical Aerospace Reports* (STAR) or in *International Aerospace Abstracts* (IAA).

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

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## TYPICAL CITATION AND ABSTRACT FROM STAR

NASA SPONSORED DOCUMENT	N76-11046 #	Georgia Inst of Tech Atlanta	AVAILABLE ON MICROFICHE
NASA ACCESSION NUMBER		STUDY OF VISCOUS FLOW ABOUT AIRFOILS BY THE INTEGRO-DIFFERENTIAL METHOD Final Report	CORPORATE SOURCE
TITLE		James C Wu and Sarangan Sampath Oct 1975 61 p refs (Grant NSG-1004)	PUBLICATION DATE
AUTHORS		(NASA-CR-145693) Avail NTIS HC \$4.50 CSCL 01A	AVAILABILITY SOURCE
CONTRACT OR GRANT		An integro-differential method was used for numerically solving unsteady incompressible viscous flow problems. A computer program was prepared to solve the problem of an impulsively started 9% thick symmetric Joukowski airfoil at an angle of attack of 15 deg and a Reynolds number of 1000. Some of the results obtained for this problem were discussed and compared with related work completed previously. Two numerical procedures were used: an Alternating Direction Implicit (ADI) method and a Successive Line Relaxation (SLR) method. Generally the ADI solution agrees well with the SLR solution and with previous results at stations away from the trailing edge. At the trailing edge station the ADI solution differs substantially from previous results while the vorticity profiles obtained from the SLR method there are in good qualitative agreement with previous results.	COSATI CODE
REPORT NUMBER		YJA	

## TYPICAL CITATION AND ABSTRACT FROM IAA

NASA SPONSORED			AVAILABLE ON MICROFICHE
AIAA ACCESSION NUMBER	A76 10264 #	Hybrid upper surface blown flap propulsive-lift concept for the Quiet Short-Haul Research Aircraft	AUTHORS
TITLE		J A Cochrane and R J Carros (NASA, Ames Research Center, Moffett Field, Calif.)	AUTHORS' AFFILIATION
MEETING DATE		<i>American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 11th, Anaheim, Calif, Sept 29-Oct 1, 1975, AIAA Paper 75 1220 9 p 5 refs</i>	NAME OF MEETING
		The hybrid upper surface blowing concept consists of wing mounted turbofan engines with a major portion of the fan exhaust directed over the wing upper surface to provide high levels of propulsive lift, but with a portion of the fan airflow directed over selected portions of the airframe to provide boundary layer control. NASA sponsored preliminary design studies identified the hybrid upper surface blowing concept as the best propulsive lift concept to be applied to the Quiet Short Haul Research Aircraft (QSRA) that is planned as a flight facility to conduct flight research at low noise levels, high approach lift coefficients, and steep approaches. Data from NASA in house and NASA sponsored small and large scale wind tunnel tests of various configurations using this concept are presented.	
		(Author)	

# AERONAUTICAL ENGINEERING

*A Special Bibliography (Suppl. 75)*

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## IAA ENTRIES

**A76-35327 # Aerodynamic measurements for an oscillating two-dimensional jet-flap airfoil** J M Simmons (Queensland, University, Brisbane, Australia) *AIAA Journal*, vol 14, June 1976, p 741-748 19 refs Australian Research Grants Committee Grant No F70/17452

The experiments described were directed toward an understanding of the jet-flap airfoil when used as a lift control device in systems for the stabilization of undesirable aeroelastic behavior of structures. The magnitude and phase of aerodynamic derivatives for small sinusoidal motions of a modified NACA 0012 airfoil with a trailing-edge jet flap have been measured in two dimensional incompressible flow. The motions are pitching about the trailing edge and translation normal to the freestream direction. Results are presented for a range of dimensionless frequency, jet strength, and Reynolds number. The apparatus and techniques used to obtain oscillatory surface pressure distributions are described. Measurements with both airfoil and jet flap held stationary agree quite well with earlier experimental and theoretical results, but care must be taken to avoid misleading separation of the boundary layer near the trailing edge at low Reynolds number. It is shown that results with an oscillating jet-flap airfoil exhibit trends with frequency which are similar to those for a conventional airfoil. These trends cannot be predicted by the potential flow theory of Spence which is limited in applicability to frequencies beyond the usual range of practical interest. (Author)

**A76-35328 # Sound generated by a single cambered blade in wake cutting** C-M Ho and L S G Kovaszny (Johns Hopkins University, Baltimore, Md) *AIAA Journal*, vol 14, June 1976, p 763-766 7 refs Research supported by the United Technologies Corp

The unsteady lift force on and the sound generated by an isolated cambered blade were measured in wake cutting, i.e., when subjected to periodic flow disturbances created by passing wakes. Depending on the orientation of the blade relative to the wake passage, significant difference was found in transient pressure signatures and in radiated sound. Furthermore, the sound field calculated from the fluctuating lift by Curle's formula did agree quite well with the measured value. (Author)

**A76-35329 # A nonasymptotic triple deck model for supersonic boundary-layer interaction** K M Tu (National Bureau of Standards, Center for Fire Research, Washington, D C) and S Weinbaum (City College, New York, N Y) *AIAA Journal*, vol 14, June 1976, p 767-775 26 refs Contract No N00014-72 A 0406 0002

This investigation presents an approximate nonasymptotic theory for the Lighthill-Stewartson triple-deck model of supersonic laminar boundary layer interaction. The emphasis of the study is on supersonic flows in the Reynolds number range between 10 to the 4th and 10 to the 6th, where the viscous sublayer is of comparable thickness to the inviscid interaction layer. The two principal simplifications of the lowest-order asymptotic theory, the neglect of

the stream-tube divergence in the inviscid interaction layer and compressibility effects in the sublayer, are examined in detail. Numerical solutions are presented for shock and wedge induced separation phenomena for Mach numbers in the range between 2 and 10. One of the results is the gradual shift from the triple-deck to the single layer description, since the Mach number increases as predicted by the recent asymptotic analysis for hypersonic interactions. The existence of supercritical subcritical jumps observed in single-layer integral theories for highly cooled wall flows is also examined.

(Author)

**A76-35334 \* # Effect of geometry modifications on effectiveness of slot injection in hypersonic flow** J N Hefner (NASA, Langley Research Center, High Speed Aerodynamics Div., Hampton, Va) *AIAA Journal*, vol 14, June 1976, p 817, 818 6 refs

The study presents wind-tunnel measurements of surface static pressures, equilibrium temperatures, and skin friction downstream of tangential slot injection into a thick turbulent hypersonic boundary layer from two modified slot configurations. The data are compared with results obtained for baseline configurations reported by Cary and Hefner (1970, 1972) to determine whether simple modifications to the slot configuration can produce improved cooling effectiveness and skin friction reduction. The baseline slot configurations are simply modified by thickening the slot lip and by elevating the location of the slot exit above the flat plate. Although the results indicate that simple modifications of the baseline slot configurations can enhance the skin friction reductions obtained with tangential slot injection, slot base drag estimates show that neither of the modifications will lessen the impact of the systems penalties for collecting, ducting, and injecting the slot air. S D

**A76-35336 \* # Wall-wake velocity profile for compressible nonadiabatic flows** C C Sun and M E Childs (Washington, University, Seattle, Wash) *AIAA Journal*, vol 14, June 1976, p 820-822 12 refs Grant No NGR 48-002-047

The paper suggests a new form of the wall wake profile which is applicable to flows with heat transfer, and for which the velocity gradient at the boundary-layer edge is zero. The modified profile which takes into account the effect of turbulent Prandtl number is found to provide a good representation of experimental data for a wide range of Mach numbers and heat transfer. The skin friction coefficient values determined by a least squares fit of the profile to the data are in good agreement with values measured by the floating element technique. The values of boundary-layer thickness determined by the fit correspond more closely to the outer edge of the viscous flow region than those obtained with earlier versions of the wall-wake profile. S D

**A76-35341 Electric field penetration into a hemispherical indentation** J Lam (Dikewood Industries, Inc., Albuquerque, N Mex) *Zeitschrift für angewandte Mathematik und Physik*, vol 27, Mar 25, 1976, p 159-167

The exact solution of the electrostatic problem for monopole antennas mounted in a hemispherical dielectric-covered indentation in an airframe is presented. An inversion transformation converts the problem to that of a grounded right angled conducting wedge fed by an electric dipole. Then reinversion of the exact wedge solution, using the Green's function of the wedge, yields the exact solution of the electromagnetic hemispherical cavity problem. The penetration

of the electric field into the hemispherical indentation is determined, and the electrostatic potential, surface charge density, and induced electric dipole are obtained in closed form  
R D V

**A76-35401 \*** Heat Transfer and Fluid Mechanics Institute, Meeting, 25th, University of California, Davis, Calif., June 21-23, 1976, Proceedings Meeting sponsored by ERDA, NASA, U S Navy, Sandia Laboratories, U S Army, and University of California Edited by A A McKillop, J W Baughn, and H A Dwyer Stanford, Calif., Stanford University Press, 1976 541 p \$20

Major research advances in heat transfer and fluid dynamics are outlined, with particular reference to relevant energy problems. Of significant importance are such topics as synthetic fuels in combustion, turbulence models, combustion modeling, numerical methods for interacting boundary layers, and light-scattering diagnostics for gases. The discussion covers thermal convection, two-phase flow and boiling heat transfer, turbulent flows, combustion, and aerospace heat transfer problems. Other areas discussed include compressible flows, fluid mechanics and drag, and heat exchangers. Featured topics comprise heat and salt transfer in double diffusive systems, limits of boiling heat transfer in a liquid-filled enclosure, investigation of buoyancy-induced flow stratification in a cylindrical plenum, and digital algorithms for dynamic analysis of a heat exchanger  
S D

**A76-35403** Bulk-parameter analysis for two-phase throughflow between parallel corotating disks W Rice, D F Jankowski, and C R Truman (Arizona State University, Tempe, Ariz.) In Heat Transfer and Fluid Mechanics Institute, Meeting, 25th, Davis, Calif., June 21-23, 1976, Proceedings Stanford, Calif., Stanford University Press, 1976, p 77-91 22 refs ERDA-supported research

Consideration of multiple-disk turbomachinery for various applications requires detailed knowledge of the flow between parallel corotating disks as a major element of such turbomachinery. An approximate analysis for the laminar or turbulent throughflow between parallel corotating disks for a primary fluid carrying solid particles is presented. The flow is modeled as one-dimensional flow of a two-phase fluid in a bulk-parameter manner. The solution method is flexible in that it allows the user to specify in each application the friction factor and/or particle drag coefficient deemed most descriptive. Typical calculated results are presented for radially outward primary flow with radially outward particle flow, radially inward primary flow with radially outward particle flow, and radially inward primary flow with radially inward particle flow. Since the pressure field and the velocity field are calculated, the results provide enough information to calculate certain items of performance of a multiple-disk turbomachine rotor  
S D

**A76-35409** Skin friction reduction by slot injection at Mach 0.8 V Zakkay and C R Wang (New York University, Westbury, N.Y.) In Heat Transfer and Fluid Mechanics Institute, Meeting, 25th, Davis, Calif., June 21-23, 1976, Proceedings Stanford, Calif., Stanford University Press, 1976, p 165-179 6 refs

Surface skin friction, boundary layer profiles, and turbulent intensity due to axially symmetric tangential slot injection into a transonic turbulent boundary layer were measured. Effects of slot height, multiple slot injection, and injection mass flow rate on the surface skin friction downstream of the slot were investigated. Surface skin friction was a function of the injection mass flow rate for the ratio of interslot distance to slot height not exceeding 40. Large normal pressure gradient and relatively large turbulent intensity were found near the slot with small injection mass flow rate, the region of high turbulent intensity moved downstream with increasing injection mass flow rate. The results with two slot injections indicated that the distance between slots should be less than 30 slot heights in order to achieve some benefits from the first slot. The skin

friction reduction obtained at transonic speed is of the same order as obtained in the hypersonic regime  
(Author)

**A76-35418 #** Numerical calculation of the three-dimensional hypersonic viscous shock layer on a sharp cone at incidence J C Adams, Jr (ARO, Inc., Arnold Air Force Station, Tenn.) In Heat Transfer and Fluid Mechanics Institute, Meeting, 25th, Davis, Calif., June 21-23, 1976, Proceedings Stanford, Calif., Stanford University Press, 1976, p 340-355 13 refs

An analysis technique applicable to the problem of hypersonic laminar flow over a sharp cone at high angles of incidence is presented. The analysis, a three-dimensional hypersonic viscous shock layer approach in conjunction with a numerical solution procedure, is shown to be both applicable and accurate based upon comparisons with surface pressure distributions, surface heat transfer distributions, overall flow field measurements, and leeward meridian profile measurements taken in a hypersonic wind tunnel. The primary analytical contribution of the present work is the development of a technique whereby initial or starting conditions for the case of sharp cone at incidence flows can be generated using the same digital computer code as for the downstream marching solution  
(Author)

**A76-35419 \*** Computation of the inviscid supersonic flow over an external axial corner P Kutler (NASA, Ames Research Center, Moffett Field, Calif.) and V Shankar (Iowa State University of Science and Technology, Ames, Iowa) In Heat Transfer and Fluid Mechanics Institute, Meeting, 25th, Davis, Calif., June 21-23, 1976, Proceedings Stanford, Calif., Stanford University Press, 1976, p 356-373 10 refs Research supported by the Iowa State University of Science and Technology and NASA

A second order finite difference procedure is used to evaluate the inviscid supersonic flowfield surrounding an external axial corner composed of swept planar compression surfaces and representing the inlets on existing high-speed aircraft. The governing partial differential equations in conservation-law form are hyperbolic with respect to the axial coordinate and are solved iteratively by means of MacCormack's algorithm. The procedure treats both the peripheral shock wave and vortical singularities as discontinuities. Numerical results are presented for two parametric studies regarding the effects on the flowfield of varying the free stream Mach number and the leading edge sweep of the horizontal wedge. Results of parametric Mach number study agree with the Mach number independence principle in that as the Mach number increases, such characteristics as shock shape, cross-flow sonic line location, and vortical singularity position approach an asymptote  
S D

**A76-35420** The finite element method in subsonic aerodynamics W G Habashi (Concordia University, Montreal, Canada) In Heat Transfer and Fluid Mechanics Institute, Meeting, 25th, Davis, Calif., June 21-23, 1976, Proceedings Stanford, Calif., Stanford University Press, 1976, p 374-389 18 refs

A finite element technique is applied to compressible and incompressible potential flows past airfoils. An asymptotic patching procedure is developed, using which the domain to solutions can be appreciably reduced. Solutions to lifting and nonlifting bodies are obtained with the aid of some simplifying techniques. The advantage of the patching procedure is that lift can be obtained without recourse to numerical integration of the pressure field over the body. A mapping concept is used to transform airfoil configurations to near circular shapes and to homogenize the gradients of the problem by condensing the regions of low gradients and magnifying those of steep gradients. The use of this mapping in combination with triangular elements formulated for cylindrical coordinates makes it possible to obtain accurate solutions. Compressible flow problems characterized by a nonlinear governing equation are solved by a novel linearization process  
V P

**A76-35421 \*** Laminar supersonic flow over a backstep - A numerical solution at higher Reynolds numbers Y Kronzon, J Rom (Technion - Israel Institute of Technology, Haifa, Israel), and A



Seginer (NASA, Ames Research Center, Moffett Field, Calif.) In Heat Transfer and Fluid Mechanics Institute, Meeting, 25th, Davis, Calif., June 21-23, 1976, Proceedings Stanford, Calif., Stanford University Press, 1976, p. 390-403 16 refs

The Allen Cheng solution of the flow over a backward facing step is extended to Reynolds numbers up to 16,000 and to inflow boundary-layer height ratios as low as 0.1 by moving the downstream boundary into the recompression region and by smoothing the resulting errors. The boundary conditions in the supersonic outer flow and the downstream boundary conditions in the wake are determined by an extrapolation procedure. Computational results are compared with relevant experimental data. Fair agreement is found between the calculated base pressures and the experimental values, whereas agreement between heat transfer rates appears to be qualitative only. SD

**A76-35422** Cross flow effects in oscillating boundary layers T. R. Gupta and D. P. Telonis (Virginia Polytechnic Institute and State University, Blacksburg, Va.) In Heat Transfer and Fluid Mechanics Institute, Meeting, 25th, Davis, Calif., June 21-23, 1976, Proceedings Stanford, Calif., Stanford University Press, 1976, p. 420-435 23 refs Grant No. AF-AFOSR 74-2651C

The response of a three dimensional boundary layer to unsteady small-amplitude oscillations of the outer flow is investigated for flows over wedges using an approach based on asymptotic expansions in powers of small parameters. Expressions are obtained for the steady and unsteady components of the motion, the unsteady three-dimensional boundary layer equations are reduced to ordinary differential equations that are integrated numerically, and solutions are derived in terms of powers of the chordwise coordinate. The analytical results are given in the form of universal functions that can be employed to estimate flow fields for a variety of airfoil configurations and oscillation conditions, numerical results are presented for the special case of a flow over a swept-back wedge. It is found that coupling of the momentum equations permits the transfer of momentum from the chordwise to the spanwise direction and that the skin friction vectors oscillate in direction. F G M

**A76-35508** The use of a Stalker-tube for studying the high-enthalpy, non-equilibrium airflow over delta wings R. J. Stalker (Australian National University, Canberra, Australia) and J. L. Stollery (Cranfield Institute of Technology, Cranfield, Beds., England) In Modern developments in shock tube research, Proceedings of the Tenth International Shock Tube Symposium, Kyoto, Japan, July 14-16, 1975 Kyoto, Shock Tube Research Society, 1975, p. 55-66 7 refs Research supported by the Australian National University and Ministry of Defence of England

Schlieren photography was used to study nonequilibrium effects on the flow over flat and caret delta wings in a free piston, reflected shock tunnel. It was shown that, for thin shock layers with large radii of curvature, the flow with free stream nonequilibrium can be correlated with a flow with an equilibrium free stream. The correlation requires that the angle of incidence in the equilibrium free stream must be greater than in the nonequilibrium stream and that the free stream enthalpy should be less than half the kinetic energy normal to the shock. The frozen enthalpy quotient plays an important role in determining the minimum incidence for which correlation is possible. B J

**A76-35536** Production and inhibition of Mach stems F. Schultz Grunow (Rheinisch Westfälische Technische Hochschule, Aachen, West Germany) In Modern developments in shock tube research, Proceedings of the Tenth International Shock Tube Symposium, Kyoto, Japan, July 14-16, 1975 Kyoto, Shock Tube Research Society, 1975, p. 356-362

Modification of shock tube walls either to generate or weaken Mach stems is discussed. The wall of a shock tube designed to produce plane shocks can be altered to support generation of Mach stems by a reflecting spherical shock, and some formulas are derived for such a modification. Generation of Mach stems can be averted or at least weakened by making tube walls rugged, fashioning pointed

corrugations on a concave wall, or by certain blunting or cambering configurations. Shadow photographs and numerical data are exhibited to illustrate the problems. R D V

**A76-35537** Experiments of reflexions of plane shock waves at cylindrical surfaces A. Lozzi and L. F. Henderson (Sydney, University, Sydney, Australia) In Modern developments in shock tube research, Proceedings of the Tenth International Shock Tube Symposium, Kyoto, Japan, July 14-16, 1975 Kyoto, Shock Tube Research Society, 1975, p. 363-368 12 refs

Transitions from regular reflection to Mach reflection when a shock wave impinges on a solid boundary are discussed for curved surfaces and compared to reflections in the case of flat surfaces. Emphasis on details of the reflection pattern is aided by using cylinders of large diameter in shock tubes. The curved boundaries modify the pressure gradient near the reflection point. The experiments show persistence of regular reflection into the expected range for Mach reflection more marked in the case of curved surfaces than in the case of flat surfaces. The persistence is considered apparent at best, while the wave system is in fact a double Mach reflection for instantaneous Mach number greater than 2.40. R D V

**A76-35538** Some new results concerning the diffraction of a shock wave around a convex corner L. Z. Dumitrescu and S. Preda (Institutul de Mecanica a Fluidelor si Constructii Aerospatiale, Bucharest, Rumania) In Modern developments in shock tube research, Proceedings of the Tenth International Shock Tube Symposium, Kyoto, Japan, July 14-16, 1975 Kyoto, Shock Tube Research Society, 1975, p. 369-377 6 refs

Based on the concept of an equivalent steady flow, exact and approximate relations are deduced for the main parameters of the diffraction pattern. Then, the equations of motion are shown to reduce to a Monge Ampère equation, whose characteristics are shown to coincide with the steady (Prandtl-Meyer) expansion fan centered at the corner. Finally, an experimental study of the boundary-layer separation is presented. It is shown that, by generating successive expansion waves (produced by further deflections of the flow), the separation can be avoided, up to large turning angles. Some practical applications are suggested. (Author)

**A76-35548** Shock tunnel experiments on hypersonic source flow past slender bodies M. Yasuhara, K. Kuwabara, S. Watanabe, M. Ikeda, and N. Onojima (Nagoya University, Nagoya, Japan) In Modern developments in shock tube research, Proceedings of the Tenth International Shock Tube Symposium, Kyoto, Japan, July 14-16, 1975 Kyoto, Shock Tube Research Society, 1975, p. 446-451 Research supported by the Ministry of Education

Hypersonic source flows past slender cone, cone-cylinder and hemisphere cylinder were studied in the conical nozzle of a shock tunnel. The Mach numbers of the oncoming flows at the nose of bodies were 7.5 and 9.5, respectively. Measured pressures along the (cone) surface in the source flow show that although the nose pressures are essentially the same as those for a parallel flow, they are significantly decreased from the parallel flow values in the downstream part as the axial distance from the nose, normalized by the source nose distance, increases beyond about 0.1. The measured pressure distribution along the cone is in good agreement with the theoretical prediction for a wide range of axial distance. (Author)

**A76-35550 \*** Use of shock tubes in high Reynolds number transonic testing W. J. Cook (Iowa State University of Science and Technology, Ames, Iowa), L. L. Presley, and G. T. Chapman (NASA, Ames Research Center, Moffett Field, Calif.) In Modern developments in shock tube research, Proceedings of the Tenth International Shock Tube Symposium, Kyoto, Japan, July 14-16, 1975 Kyoto, Shock Tube Research Society, 1975, p. 472-479 13 refs

The shock tube as a device to fulfill current needs for testing of transonic airfoils at high Reynolds numbers is considered. Per

formance analysis of a gas-driven shock tube shows that transonic airfoil flows with chord Reynolds numbers in the range of 100 million can be produced. A study of flow development over a simple airfoil has been carried out in a shock tube at low and intermediate Reynolds numbers to assess the testing technique. Results obtained from schlieren photography and airfoil pressure measurements show that steady transonic flows similar to those produced for the same airfoil in a wind tunnel can be generated within the available testing time in a shock tube with properly contoured test section walls. The study indicates that the shock tube is a viable alternative as a facility for studying high Reynolds number transonic airfoil flows. (Author)

**A76-35551** Some flow patterns observed in shock tubes and the comparison with results by numerical simulation. K Oshima (Tokyo, University, Tokyo, Japan). In: Modern developments in shock tube research, Proceedings of the Tenth International Shock Tube Symposium, Kyoto, Japan, July 14-16, 1975. Kyoto, Shock Tube Research Society, 1975, p 480-487. 12 refs

Some flow patterns observed in shock tubes are presented and it is discussed that there are two distinct categories of these flow patterns, the wave interaction mode and the stationary flow mode. The former can be successfully treated by the ray-shock theory, on which some improvements are also mentioned. The latter flow is reached after a transient process which is closely related to the time proceed method in the numerical analysis of flow field. Close correlations between the observed flow pattern and the numerical results are suggested. (Author)

**A76-35552** Jet noise research by means of shock tubes. H Oertel (Institut Franco-Allemand de Recherches, Saint-Louis, Haut-Rhin, France). In: Modern developments in shock tube research, Proceedings of the Tenth International Shock Tube Symposium, Kyoto, Japan, July 14-16, 1975. Kyoto, Shock Tube Research Society, 1975, p 488-495. 11 refs

The ISL-high pressure shock tube has been used for studying the wave angles of straight waves emitted from cold and hot supersonic free jets. Difficulties encountered with turbulence hiding the waves have been overcome by means of new visualization techniques. A simple relation has been found between wave angle, jet Mach number and sound velocity ratio, which agrees well with a theoretical model. (Author)

**A76-35703** # Three-dimensional steady gas flows with straight isohypse lines in the presence of the Bernoulli integral (O prostranstvennykh ustanovivshikhsia tekheniakh gaza s priamymi liniyami urovnia pri nalichii integrala Bernulli). E N Zubov (Akademii Nauk SSSR, Institut Matematiki i Mekhaniki, Sverdlovsk, USSR). *Akademii Nauk SSSR, Doklady*, vol 227, Mar 1, 1976, p 57-59. In Russian

A complete classification is presented of three-dimensional steady flows with straight isohypse lines of the flow parameters in the presence of the Bernoulli integral. It is shown that for a specific heat ratio of 2, there exists a class of supersonic vortex flows that depend on two arbitrary functions of one variable. An exact solution representing a supersonic conical vortex flow is obtained as an example. V P

**A76-35748** Rotary wing aircraft (Drehflügel-Flugzeuge). G Reichert (Messerschmitt Bolkow-Blohm GmbH, Ottobrunn, Darmstadt, Technische Hochschule, Darmstadt, West Germany). *VDI-Z*, vol 118, no 11, June 1976, p 541-544. 58 refs. In German

The author discusses briefly some of the main trends in civil and military helicopter design and technology, providing an extensive bibliography of works describing in detail the developments over the past few years. The trend toward hingeless rotors is signaled and, regarding hinged rotors, the move to elastic stiffeners and elastomer bearings. Various rotor heads are being made of titanium alloys, while even fiber-reinforced plastics have been tested for this purpose.

A clear trend to the use of fiber-reinforced plastics and composites is seen. Developments in helicopter research, including aerodynamic theory, noise studies, and structural investigations, are also mentioned. P T H

**A76-35829** # Momentum flux development from three-dimensional free jets. J P Narain (Colorado, University, Boulder, Colo.). *American Society of Mechanical Engineers, Paper 76-FE E*, 1976. *ASME, Transactions, Series I - Journal of Fluids Engineering*, vol 98, June 1976, p 256-260. Discussion, p 260. Author's Closure, p 260. 20 refs. Project SQUID

The momentum flux development from three-dimensional free jets has been investigated. The analysis is presented for free jets from circular, triangular, rectangular and elliptical orifices. The bluff jets, with eccentricity near unity, show the usual potential region and the axisymmetric decay region for the maximum axial velocity decay. The slender jets, with smaller than one eccentricity values, show three zones of flow development. The potential core region is followed by a characteristic decay region where velocity decay is dependent on the shape and eccentricity of the orifice. The maximum axial velocity of all slender jets finally decay axisymmetrically with increasing downstream distances. (Author)

**A76-35835** # A note on the two-dimensional cylinder wake. S Fujii and M Gomi (National Aerospace Laboratory, Chofu, Tokyo, Japan). *ASME, Transactions, Series I - Journal of Fluids Engineering*, vol 98, June 1976, p 318-320. 5 refs

Experimental data are reported on the interaction of wakes shed from two arbitrarily spaced cylinders. The dependences of mean velocity, turbulent kinetic energy, and shear stress on the spacing are plotted, and show appreciable changes in the distribution of flow properties at small spacings. The low speed wind tunnel test data fill a gap in information of wakes shed from two-dimensional bodies spaced close together and aid calculations of the near wake with rapidly decayed turbulence downstream. Nonlinear interaction between the wakes downstream is observed at close cylinder spacings. R D V

**A76-35836** # Analysis of turbulent unseparated flow in subsonic diffusers. P T Harsha (R & D Associates, Marina del Rey, Calif.) and H N Glassman (ARO, Inc., Arnold Air Force Station, Tenn.). *ASME, Transactions, Series I - Journal of Fluids Engineering*, vol 98, June 1976, p 320-322. 8 refs

The flow field for turbulent unseparated flow in subsonic diffusers of arbitrary geometry is divided into parabolic and elliptic regions and calculations are performed for the parabolic flow. The turbulent shear stress field throughout the diffuser is calculated with the aid of a turbulent kinetic energy (TKE) method. Analysis of the diffuser flow field is similar to TKE treatment of free mixing flow fields, and remaining discrepancies are examined in the article (wall shear stress requires analysis, and the dissipation length scale in the TKE transport equation is modeled). Predicted and empirical pressure rise, boundary layer thickness, and wall skin friction are compared. Flow in an unstalled subsonic diffuser is accurately predicted to a point near the onset of separation of flow. Constants in the TKE equation also apply to jet and wake flows, wall boundary layer flows, and momentumless flows, with satisfactory results. R D V

**A76-35842** Prediction of recirculating, swirling, turbulent flow in rotating disc systems. A D Gosman, F C Lockwood (Imperial College of Science and Technology, London, England), and J N Loughhead. *Journal of Mechanical Engineering Science*, vol 18, June 1976, p 142-148. 15 refs

A two-dimensional finite difference method developed by Gosman et al (1969) was used to study the recirculating swirling turbulent flow between rotating and shrouded stationary disks with an axial source flow. A turbulence model involving the solution of two differential equations was used to calculate turbulent transport.

processes Predicted disk torque was shown to agree well with experimental data B J

**A76-35844** An alternative scheme to solve the equations for unsteady gas flow J F T MacLaren, A B Tramschek, O F Pastrana (Strathclyde, University, Glasgow, Scotland), and A Sanjines (Los Andes, Universidad, Bogota, Colombia) *Journal of Mechanical Engineering Science*, vol 18, June 1976, p 161-163 5 refs

A combined numerical scheme for solving the equations which describe the nonhomotropic unsteady gas flow in a reciprocating gas compressor is proposed The scheme uses the leap-frog method in the pipes and the method of characteristics at the boundaries and is found to be as accurate as the composite Lax-Wendroff/characteristics scheme and requires less computational time B J

**A76-35850 \*** A model-based analysis of a display for helicopter landing approach R A Hess and L W Wheat (US Naval Postgraduate School, Monterey, Calif) *IEEE Transactions on Systems, Man, and Cybernetics*, vol SMC-6, July 1976, p 505-511 5 refs NASA-supported research

A control theoretic model of the human pilot was used to analyze a baseline electronic cockpit display in a helicopter landing approach task and to generate display quickening laws designed to improve pilot-vehicle performance A simple fixed base simulation provided comparative tracking data which allowed refinement of the pilot model (Author)

**A76 35861 #** The economics, organization and planning of aircraft production (Ekonomika, organizatsiya i planirovaniye aviatzionnogo proizvodstva) D E Starik, F I Paramonov, and I I Bugakov Moscow, Izdatel'stvo Mashinostroeniye, 1976 384 p 23 refs In Russian

The book provides an analysis of the role of aircraft production in the national economy of the USSR, and its relationship to other heavy industry Methods of organizing and planning the production of a multicomponent aircraft are given for the overall project and for individual components and subsystems Particular attention is allocated to proper assignment of available manpower and to the physical layout of production units, determination of the time to be allowed for completion of the different stages of work is considered in detail Economic models for assessing the cost effectiveness of a new technology are outlined The administration of support functions, such as the production of spare parts and the maintenance and quality control of completed aircraft, is discussed C K D

**A76-35890 #** Noise and structure of gas flow during critical throttled discharge from a disk with multiple openings (Halas i budowa strumienia gazu przy krytycznym dławionym wypływie z tarczy wielootworowej) W M Jungowski and W C Selerowicz (Warszawa, Politechnika, Warsaw, Poland) *Archiwum Akustyki*, vol 11, no 2, 1976, p 117-139 13 refs In Polish

The paper describes a theoretical and experimental study of a disk with multiple openings as a means of exhaust noise reduction during critical throttled discharge of a gas The experimental part involved measurements of noise levels as a function of discharge rate and the number, spacing, and diameter of the openings on the disk The range of values of these parameters ensuring efficient noise suppression is determined P T H

**A76-35971** Development of an advanced composite rudder for flight service on the DC-10 G M Lehman (Douglas Aircraft Co., Long Beach, Calif) *Society of Manufacturing Engineers, Conference on Advanced Composites Design, Manufacture and Application, Los Angeles, Calif, June 1-3, 1976, Paper EM76-416* 15 p

Design synthesis, manufacturing development, and ground tests

of an advanced composite rudder for the DC-10 are discussed The composite structure was designed and fabricated using a unique processing method in which the thermal expansion characteristics of rubber tooling mandrels were used to generate curing pressures during an oven cure cycle This method eliminated the need for autoclave curing and secondary assembly bonding of the rudder structure Development of the rudder is traced through construction and testing of fabrication feasibility specimens and development components representing salient details of the structure Development of the rudder tooling and manufacturing process is described Processing, tooling, and manufacturing problems encountered during fabrication of the graphite rudders and the results of corrective actions are discussed (Author)

**A76-35972** Manufacturing view of primary composite structure for B-1 aircraft H Borstell (Grumman Aerospace Corp., Bethpage, N Y) *Society of Manufacturing Engineers, Conference on Advanced Composites Design, Manufacture and Application, Los Angeles, Calif, June 1-3, 1976, Paper EM76-417* 11 p

The Composite B 1 Horizontal Stabilizer was designed to meet all aircraft structural requirements in a cost effective manner The design manufacturing interface resulted in a significant reduction in the part count and costs compared to the metal structure Single cure processing of substructure components, semi automatic drilling, and high tolerance detail parts was emphasized to maximize production implementation The resulting composite design has demonstrated a weight savings of 15% for the total flightworthy stabilizer and 21% for the composite box over the existing metal configuration Cost savings of 17% are forecasted for production The full-scale static article failed at 132% of DUL which verified the design manufacturing concept (Author)

**A76-35997** The production of kinetic energy turbulence in supersonic separated flows (Sur la production de turbulence d'énergie cinétique dans un écoulement séparé, à vitesse supersonique) J Gaviglio, J P Dussauge, J F Debieve, and A Favre (Aix-Marseille, Université, Marseille, ONERA, Châtillon sous Bagneux, Hauts-de-Seine, France) *Académie des Sciences (Paris), Comptes Rendus, Serie B - Sciences Physiques*, vol 282, no 19, May 17, 1976, p 445-450 14 refs In French

Study of the turbulence production equation with two terms, one for kinetic energy production and the other for enthalpy production, is carried out for a supersonic flow slightly out of equilibrium The effects of compressibility and pressure gradients, including those due to curvature, are detailed, and the production terms are compared The behavior of the terms is studied in various regions of the flow in the turbulent boundary layer that has separated from the back of a circular dart situated along the axis of a supersonic wind tunnel P T H

**A76-36095** Vertical takeoff and landing aircraft (Vertikal startende und landende Flugzeuge) S Harmsen (Berlin, Technische Universität, Berlin, West Germany) *VDI-Z*, vol 118, no 12, June 1976, p 591-593 22 refs In German

Questions concerning the economic factors of VSTOL operation are examined It is pointed out that for an employment of VSTOL aircraft in short haul operations it will be necessary to improve the efficiency of the aircraft propulsion system Attention is also given to the solution of problems related to the recirculation of the hot gases, induced forces and stresses affecting the aircraft at takeoff and landing, and the aerodynamics for the transition from the jet supported flight to the second flight phase G R

**A76-36132 \*** On the flow in an annulus surrounding a whirling cylinder C Brennen (California Institute of Technology, Pasadena, Calif) *Journal of Fluid Mechanics*, vol 75, May 13, 1976, p 173-191 9 refs Contracts No N00014 76 C-0157, No NAS8 28046

When fluid in an annulus between two cylinders is set in motion by whirling movements of one or both of the cylinders, dynamic forces are imposed by the fluid on the cylinders. Knowledge of these forces is frequently important, indeed often critical, to the engineer designing rotor systems or journal bearings. Quite general solutions of the Navier-Stokes equations are presented for this problem and are limited only by restrictions on the amplitude of the whirl motion. From these solutions, the forces are derived under a wide variety of circumstances, including large and small annular widths, high and low Reynolds numbers, and the presence and absence of a mean flow created by additional net rotation of one or both of the cylinders.

(Author)

**A76-36158 \* #** Application of optimal input synthesis to aircraft parameter identification N K Gupta, W E Hall, Jr (Systems Control, Inc., Palo Alto, Calif.), and R K Mehra (Harvard University, Cambridge, Mass.) (*American Society of Mechanical Engineers, Paper 76-Aut-U, 1976*) *ASME, Transactions, Series G - Journal of Dynamic Systems, Measurement, and Control*, vol 98, June 1976, p 139-145. 13 refs. Contracts No. NAS4 2068, No. N00014 75-C 0818.

The Frequency Domain Input Synthesis procedure is used in identifying the stability and control derivatives of an aircraft. By using a frequency-domain approach, one can handle criteria that are not easily handled by the time-domain approaches. Numerical results are presented for optimal elevator deflections to estimate the longitudinal stability and control derivatives subject to root mean square constraints on the input. The applicability of the steady state optimal inputs to finite duration flight testing is investigated. The steady state approximation of frequency domain synthesis is good for data lengths greater than two time cycles for the short period mode of the aircraft longitudinal motions. Phase relationships between different frequency components become important for shorter data lengths. The frequency domain inputs are shown to be much better than the conventional doublet inputs.

(Author)

**A76-36160 \* #** Optimal command generation for tracking a class of discontinuous trajectories S Weissenberger (Santa Clara, University, Santa Clara, Calif.) (*American Society of Mechanical Engineers, Paper 76-Aut-R, 1976*) *ASME, Transactions, Series G - Journal of Dynamic Systems, Measurement, and Control*, vol 98, June 1976, p 167-172. 13 refs. Grant No. NSG 2106.

Commands are found to drive a linear system to optimally track a class of prescribed trajectories, each of which contains a point of discontinuity. The paper focuses on the guidance problem of command generation, to be implemented in a feedforward fashion, the necessary additional control or feedback regulation structure is not studied in detail, but assumed to be provided in applications as a conventional error-feedback regulator. Solutions are found for the infinite-time problem which are optimal with respect to a quadratic performance criterion, suboptimal controls which satisfy a continuity condition are also found. The controls have applications to certain problems in aircraft guidance where command trajectories are piecewise continuous. Several examples are worked out in detail, with comparisons with conventional, nonfeedforward solutions to the problem, and a brief discussion of a simpler, suboptimal solution.

(Author)

**A76-36222** A reliability case history The F 15A Eagle Program D Malvern (McDonnell Aircraft Co., St. Louis, Mo.) *Defense Management Journal*, vol 12, Apr 1976, p 40-45.

It is described how the excellent base of reliability data accumulated during the design of the F 4 Phantom was applied to the reliability design of the F 15A Eagle with 111 separate MTBF guarantees included in the program. Improvements of the F 15A reliability over that of the F 4 were achieved in the following areas: solid state sensors, solid state switching, digital circuits, wiring, simplicity, redundancy, hydraulic systems, dual electric generators and mechanical and electronic control augmentation systems. Over

130,000 avionics test hours and 3,800 flight hours were accumulated for reliability verification of the MTBF guarantees.

B J

**A76-36373 #** Experimental study of a cavitating arched wing of finite span (Eksperimental'noe issledovanie kavitiruiushchego dugovogo kryla konechnogo razmakha) L I Mal'tsev and N A Sadvovskaia (Akademiia Nauk SSSR, Institut Teplofiziki, Novosibirsk, USSR) *Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriya Tekhnicheskikh Nauk*, Feb 1976, p 81-84. In Russian.

Two series of experiments were conducted on cavitating wings with a midline bent in the plane perpendicular to the velocity vector of the flow. In one series of hydroplane experiments, the wing surface was conical and the angle of attack was held constant, while in the other series, the wing surface was cylindrical and the angle of attack was varied. The cavitating flow regime was achieved by injecting air to the trailing edge of the wings. A tensometric dynamometer located inside the ellipsoid of revolution was used to measure the longitudinal (drag) and transverse (lift) components of the hydrodynamic force. Dimensionless drag coefficients are plotted for the different wings tested. It is shown that an arched wing with constant angle of attack has a 50% higher lift coefficient in cavitating flow.

B J

**A76-36401** Long-term properties of some heat-resistant and high-temperature materials II - Findings in strength studies at different temperatures (Langzeiteigenschaften einiger warmfester und hochwarmfester Werkstoffe II - Ergebnisse aus Festigkeitsuntersuchungen bei verschiedenen Temperaturen) H Wiegand and O Jahr (Darmstadt, Technische Hochschule, Darmstadt, West Germany) *Zeitschrift fur Werkstofftechnik*, vol 7, June 1976, p 212-219. In German. Research supported by the Bundeswirtschaftsministerium.

Relationships between fatigue strength and creep behavior of some common engineering and structural materials are investigated at different temperatures, with attention given to brittle fracture in originally ductile materials subjected to creep under tensile load. Several high-temperature alloys fabricated for service in admission and exhaust valves, diesel precombustion chambers, gas turbine parts and blading were studied after heat treatment or solution anneal. Creep curves are plotted for plain and notched samples.

R D V

**A76-36544 #** Problems in the simulation of controllable flight vehicles (Probleme der Simulation von Lenkflugkorper-systemen) H Schubert (Deutsche Forschungs und Versuchsanstalt fur Luft und Raumfahrt, Institut fur Dynamik der Flugsysteme, Oberpfaffenhofen, West Germany) *Deutsche Gesellschaft fur Luft- und Raumfahrt, Symposium uber Flugkorper-Simulation, Cologne, West Germany, Apr 8, 1976, Paper 76-050*. 7 p. In German.

The application of digital, analog, and hybrid computers to the simulation of aircraft and weapon systems is examined, and the principles of simulation with allowance for internal and external influences and disturbances are outlined. The developmental stage of simulating a given model, the simulation possibilities, and the advantages which accrue from simulation are discussed. The prerequisites for proper simulation and the procedures of the simulation process are examined.

V P

**A76-36545 #** The case for the wide-bodied airship for heavy lift applications L C Laming and G W Tunley (Imperial College of Science and Technology, London, England) *Deutsche Gesellschaft fur Luft- und Raumfahrt, Symposium uber Flugkorper-Simulation, Cologne, West Germany, Apr 8, 1976, Paper 27*. 7 refs.

The problem of loading and unloading conventional Zeppelin type airships is discussed, and it is suggested that the 'wide-body' airship can overcome this problem. A mooring technique is proposed for the wide-body airship, possibilities for a low-weight structure are considered, and a hexagonal cellular structure is described. The aerodynamic implications of the wide body airship are examined, design criteria are outlined, and an economic analysis is performed.

for a wide-body airship with a gross volume of 45 million cu ft, a gross weight of 945 tons, a useful load of 400 tons, a design altitude of 5000 ft, and a speed of 70 to 90 mph. The costs of operating this wide-body airship and a Zeppelin type airship with the same parameters are compared. F G M

**A76-36546 # Aerial combat simulation in industry from the preparatory phase to the development (Luftkampsimulation bei der Industrie vom Phasenvorlauf bis zur Entwicklung).** W. Günther (Dornier GmbH, Friedrichshafen, West Germany) *Deutsche Gesellschaft für Luft- und Raumfahrt, Symposium über Flugkörper-Simulation, Cologne, West Germany, Apr 8, 1976, Paper 76-053* 21 p. In German.

It is pointed out that the simulation of aerial combat, on account of its complexity, is to a large degree independent of its application in the various phases of the development of an air to air missile. The given description of the employment of aerial combat simulation for an air to air missile is, therefore, also representative for an application of the simulation during the other phases. Attention is given to three parameters, including the distance between the two aircraft engaged in the combat, the off the tail angle, and the angle between the longitudinal aircraft axis and the line of sight to the enemy aircraft. G R

**A76-36547 # Representation of the activities of defense-technology-related simulation for the BMVg during the EB-MAT (Darstellung der Aktivitäten der wehrtechnischen Simulation für das BMVg im Verlauf des EB-MAT)** H. M. Franke (Industrieanlagen-Betriebsgesellschaft mbH, Ottobrunn, West Germany) *Deutsche Gesellschaft für Luft- und Raumfahrt, Symposium über Flugkörper-Simulation, Cologne, West Germany, Apr 8, 1976, Paper 76-048* 31 p. 13 refs. In German.

A survey is presented of the activities involved in simulations undertaken for the Ministry of Defense of West Germany in connection with the development and the supply of material for the armed services. Simulation processes related to the development and the use of ballistic missiles are considered. Studies conducted to determine questions concerning the technical implementation are discussed. Attention is given to the technical data required, the methods employed by the engineer, and the simulation studies carried out during the phases of equipment development. G R

**A76-36556 Landing of flight vehicle with controllable shock absorption.** N. V. Gerasimov (*Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela*, Sept-Oct 1975, p. 58-62) *Mechanics of Solids*, vol. 10, no. 5, 1975, p. 49-53. Translation.

Analytic control theory is applied to the optimal change of viscous resistance in the shock absorber during the landing of a flight vehicle with arbitrary vertical landing speed, lift force, and landing weight. Optimal control in this case means that the absorption of the kinetic energy of the first landing impact is accomplished with minimal overload, and the recovery of the vehicle to static stability is accomplished in minimal time without the presence of vertical oscillations. A shock absorber with programmed control of the dissipative force has been tested on an aircraft landing simulator. B J

**A76-36561 Some problems of aeroelasticity with separated flow.** S. M. Belotserkovskii, A. S. Vol'mir, M. I. Nisht, and A. T. Ponomarev (*Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela*, Sept-Oct 1975, p. 150-157) *Mechanics of Solids*, vol. 10, no. 5, 1975, p. 126-132. 9 refs. Translation.

Various flutter problems are solved by a combination of numerical methods of nonlinear wing theory and the nonlinear theory of shells and plates. The nature of aerodynamic loading is defined, and some models of the aeroelastic behavior of various aircraft structures in separated flow are considered. These include buffeting of the tail surface, the flutter of a lifting surface panel, and a thin spherical shell section undergoing axisymmetric translational motion. B J

**A76-36581 Design for regulatory compliance - A designer's viewpoint.** J. F. Sutter (Boeing Commercial Airplane Co., Renton, Wash.) *Society of Automotive Engineers, Air Transportation Meeting, New York, N.Y., May 18-20, 1976, Paper 760501* 17 p.

Dramatic improvements in null loss rates for commercial transport aircraft have been achieved in the past 20 years, as the result of the supreme design priority accorded to safety. Steady progress has been made in the development of Federal Aviation Administration (FAA) standards. Continued improvement of the operational safety of transport aircraft is dependent on the economic health of the airlines. Some problems in the process of type certification are identified and discussed. These include the time lag in FAA response in such matters as interpretation of safety regulations, controversial subjects, and special conditions. Lack of coordination between the FAA, the Environmental Protection Agency, and other agencies, and lack of defined and proven test procedures hinder evaluation of compliance with newly established noise standards. It is recommended that in cases in which FAA design regulations are demonstrably exceeded, appropriate allowances be made in determining maximum passenger load. C K D

**A76-36582 A systems approach to aviation safety.** FAA comments on design for regulatory compliance - A safety system. R. H. Stanton (FAA, Hawthorne, Calif.) *Society of Automotive Engineers, Air Transportation Meeting, New York, N.Y., May 18-20, 1976, Paper 760500* 6 p.

The procedures by which the Federal Aviation Administration (FAA) ensures that aircraft and aircraft systems and appliances conform to safety regulations during development, production, and use are briefly summarized. Design approval for the development of a new civil aeronautics product is given in the form of an FAA Type Certificate in the case of a new aircraft model, and in the form of a Technical Standard Order or letter of design approved for other aeronautics products. A Type Certification Board is then established to oversee compliance with FAA requirements. Conformity inspection and flight tests are supervised by the FAA, and upon finalization and approval of the design and flight manual, a Type Certificate is issued. The procedures used in production and quality control of the aircraft are closely monitored by the FAA, and each completed aircraft must be issued a Certificate of Airworthiness before operation. The FAA works closely with the manufacturer and airlines to identify and correct design problems appearing in a given model in prolonged use. C K D

**A76-36583 A worldwide system to ensure a satisfactory level of safety.** C. P. J. Frantzen (Secretariat d'Etat aux Transports, Paris, France) *Society of Automotive Engineers, Air Transportation Meeting, New York, N.Y., May 18-20, 1976, Paper 760503* 5 p.

Differences in safety objectives and lack of confidence are the two major obstacles which could have prevented the international development of civil aviation. From the Chicago Convention to the European Joint Airworthiness Requirements, these obstacles have been overcome to the satisfaction of all nations. This stands as an example not only for other aviation matters, but for any field of technical activities faced with international regulatory problems. (Author)

**A76-36584 Improved maintenance practices - The airlines' contribution to lower ownership costs.** K. Grayson (American Airlines, Inc., New York, N.Y.) *Society of Automotive Engineers, Air Transportation Meeting, New York, N.Y., May 18-20, 1976, Paper 760504* 11 p.

In order to conserve fuel and lower ownership costs, airlines have introduced various programs related to aircraft operation, fuel management, and engine performance efficiency. Attention is given to computerized flight planning, an aircraft performance trend monitor program, a condition engine monitor log, engine performance restoration programs, the establishment of optimum speeds for all types of aircraft, and the development of viable

diagnostic systems The experience of the airlines related to aircraft operation has been utilized in engine designs which make it possible to reduce maintenance and, therefore, airline ownership costs Aspects of airline management philosophy are also discussed along with questions of fiscal maturity and problems of propulsion system design G R

**A76-36585** Maintenance - An investment process F B Gattis and G P Sallee (United Technologies Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.) *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760505* 7 p

The relationship between cost per repair and mean time between repair is examined Engine maintenance cost data (direct labor, material, and outside repair costs) and engine flight hour data for six domestic airlines are compared Results for the JT8D engine indicate a direct relationship between the amount spent per repair and the length of time between shop visits Investing more in individual repairs may result in long-term reductions of operating costs C K D

**A76-36586** The influence of microcomputer technology on propulsion management system design R D Porter (United Technologies Corp., Hamilton Standard Div., Windsor Locks, Conn.) *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760507* 11 p

The paper discusses the use of digital microcomputer technology for aircraft engine and fuel control, with supervisory control of the F 100 engine used as an example Topics touched upon include semiconductor memory technology, the design of electronic supervisory controls, electronic propulsion system control, reliability design, fault compensation logic, the reduction of unscheduled shutdowns through redundancy and extended operation following a failure B J

**A76-36587** Economic benefits of digital electronic propulsion controls for advanced commercial aircraft G J Sevich and D M Newirth (United Technologies Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.) *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760508* 9 p 6 refs

Economic advantages of digital electronic controls over their hydromechanical counterparts for commercial aircraft propulsion applications are discussed The discussion covers control system comparison, engine maintenance, fuel consumption, control system maintenance cost, delay and cancellation data, and credibility of predictions The cost studies predict significant benefits if digital controls replace conventional hydromechanical controls in advanced transport engines As much as 50% improvement in hot section life can be anticipated due to more accurate thrust control Fuel consumption may be reduced by 1% due to increased control capability and reduction in trim requirements Maintenance cost for the control system itself may be lowered as much as 50% Delays and cancellations chargeable to the control system can be reduced by a factor of 3 However, the estimates must be assessed with caution since they are necessarily based on unsubstantiated reliability and cost predictions S D

**A76-36588** Air transport propulsion improvement opportunities with advanced controls F C Gray (Douglas Aircraft Co., Long Beach, Calif.) *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760509* 12 p 5 refs Research sponsored by the McDonnell Douglas Independent Research and Development Program

A survey of twelve commercial airlines was conducted to evaluate the performance of current propulsion control systems (PCS) and to identify priority target areas for research and development Eight airplane types, representing the three generations of gas turbine powered commercial transports put into service since 1958, were included in the study Major problem areas in third generation subsonic transport PCS, in descending order of relative need for improvement, are the thrust command links, the auto-throttle system, the engine electrical-output sensors, and the thrust

levers Airline preferences with regard to different design alternatives to alleviate specific problems in these priority areas are analyzed, and general requirements for a PCS based on 1985 technology are developed C K D

**A76-36589** Dynamic technical tools - Or Dead Sea scrolls W L McAllister (Flying Tiger Line, Inc., Los Angeles, Calif.) *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760511* 6 p

A review of cost effects of statistical reporting technology in on-condition monitoring of airline control procedures, accompanying the transition from hard-time maintenance programs to condition monitoring systems, is advised, along with recommendations aimed at keeping the paperwork explosion within bounds Types of reliability report formats and displays are analyzed and catalogued Practical DOs and DON'Ts are listed as guidelines in cost control and volume control of statistical reports R D V

**A76-36590** Management of service deficiencies - A component manufacturer's view R C Curry (Garrett Corp., Los Angeles, Calif.) *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760512* 7 p

The control steps for the design and development of a multicomponent integrated aircraft, including component testing, system testing, and flight testing, are briefly outlined Following introduction of a new aircraft into service, it is essential that component and system deficiencies be identified and corrected as soon as possible The cause of performance problems reported by the flight crew is investigated by the maintenance staff and representatives of the airframe manufacturer, engine manufacturer, and the suppliers of principal components and aircraft systems Data collected from the airlines using the new model is evaluated to reveal serious deficiencies, and appropriate corrective action is taken according to the source of the problem lack of design features effectiveness, lack of maintenance supervision effectiveness, or deficiencies in the training of maintenance personnel C K D

**A76-36591** An aircraft manufacturer's view of service problems and their correction E A Green and A S Lied (Lockheed California Co., Burbank, Calif.) *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760513* 10 p

The high equipment investment cost of today's large transport aircraft, the high daily utilization desired or required for profitable operations, and the potential revenue losses associated with service interruptions make it mandatory for the manufacturer to take an active part in the early reduction and correction of service problems This paper deals with an aircraft manufacturer's approach to meeting this challenge The accumulation and evaluation of service data are discussed together with the investigations initiated to properly understand the problem, and the management procedures established to assure a safe and speedy problem resolution with a minimum of service interruption Specific examples are used to illustrate the types of decisions reached The continuous coordination effort required between the aircraft manufacturer and its subcontractors to attain and exceed service reliability objectives is considered (Author)

**A76-36592** Managing service deficiencies A pilot perspective G T Henderson and D G Teuscher (United Airlines Inc., Chicago, Ill.) *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760514* 10 p

The role of the Captain in the preservation of service quality and safety is discussed The materials used by the Captain in assessing the capability of his aircraft to complete a given mission safely are outlined, with special attention given to the use of the Minimum Equipment List Communication between pilots and manufacturers on the subject of design deficiencies is stressed Factors adversely affecting the ability of the pilot to deal effectively with deficiencies including poor dispatch planning, a surfeit of bells, horns and lights in the cockpit even under normal operating conditions, and warning

system inaccuracy, are considered, together with the consequences of derivative technology and aging transport fleets C K D

**A76-36593** Integrated engine inlet thermal anti-icing and environmental control system /TAI/ECS/ A D Shah (Boeing Commercial Airplane Co., Renton, Wash.) *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760517* 7 p

The integrated engine inlet thermal anti-icing and environmental control system (TAI/ECS) for subsonic transport airplanes was conceived primarily for the efficient use of available energy and minimum engine bleed air extraction. The concept employs the engine inlet leading edge as the heat exchanger to provide ice protection for the engine inlet surfaces and to cool bleed air for the environmental control system. The results of a study conducted for a typical wide body airplane using high bypass ratio engines show that the system concept will result in potential improvements in airplane operation and engine maintenance (Author)

**A76-36594** Environmental regulations and their impact on airport development J R Goodwin and L P Sparks (FAA, Washington, D C) *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760518* 9 p

The protection and preservation of environmental quality in the expansion and improvement of the Nation's airport system are major goals of the Federal Aviation Administration's Airports Program. There are many environmental laws and regulations, the most outstanding being the National Environmental Policy Act of 1969, which impose requirements on proposed airport projects and which must be complied with before Federal approval can be given. The paper is a survey of environmental regulations that affect airport development. It is primarily presented from the Federal viewpoint although regional, state, and local requirements are cited. The implications for airport development of each regulation are briefly described. The paper concludes with a general commentary on the impact of environmental values and requirements on airport actions (Author)

**A76-36595** Feasibility demonstration of a turbine engine rotor mounted electrical generator J H Dower (United Technologies Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.) *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760520* 11 p

A feasibility demonstration featuring the integration of a 30 kva electrical generator into a gas turbine engine was successfully completed. The test results demonstrated adequacy of the selected electrical, magnetic and thermal designs. The mechanical design was satisfactory except for a discrepancy in securing the permanent magnet to the generator rotor. Establishing the practicality of integral generators in gas turbines is a step toward improving aircraft and propulsion performance by reducing frontal area, engine and accessory weight and engine airflow blockage by the tower shaft shroud. However, these advantages don't necessarily justify universal adoption. Each prospective application must be confirmed by the increasingly complex process required to optimize aircraft internal power systems (Author)

**A76-36596 \*** Powered wheels for aircraft M J Long (NASA, Langley Research Center, Hampton, Va.) *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760521* 7 p NASA-supported research

Engineering details, project status, system design and specifications, and test results are presented on a powered wheel drive system based on the Dynavector rotary actuator. The design and operation of the Dynavector system (with positive displacement very low-inertia nonrotating vane motor) are reviewed. Feasibility studies,

contract data, and findings of braking tests are described. Exploded diagrams of Dynavector details are displayed. Success in using powered wheels in lieu of aircraft main engines for on ground movements should bring benefits in energy conservation, noise abatement, reduced pollution, and alleviated congestion in the terminal area R D V

**A76-36599 \*** Construction and verification of a model of passenger response to STOL aircraft characteristics I D Jacobson (Virginia, University, Charlottesville, Va.) *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760525* 7 p 10 refs Grant No NGR-47 005-181

A technique for evaluating passenger acceptance of a transportation system's environment has been developed. This includes a model of passenger reaction to the vehicle, as well as the relative satisfaction compared to other system attributes. The technique is applied to two commercial airline operations - a US commuter, and the Canadian Airtransit STOL system. It is demonstrated that system convenience and aircraft interior seating can play a large role in satisfying the passenger (Author)

**A76-36600** Passenger acceptance of STOL - The Airtransit view R B McCormack (Airtransit Canada, Ltd., Montreal, Canada) *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760526* 11 p

**A76-36601** Aircraft kerosene vs wide-cut fuel - Safety considerations H W Carhart (US Navy, Naval Research Laboratory, Washington, D C), J H Warren (Mobil Sales and Supply Corp., New York, N Y), and I Pintel *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760527* 19 p 24 refs

The effect of fuel type on post-crash survivability is investigated on the basis of data from 200 impact survivable accidents in which fuel was spilled. In crashes at or near the airport in which fuel is spilled, kerosene type Jet A fuel appears to be safer than wide cut type Jet B fuel with a high degree of statistical confidence. In in-flight accidents the probability of fire is lower and survival higher for Jet A fuel, and this fuel is also safer for servicing and maintenance operations. It is predicted that an intermediate volatility fuel of 80-90 F flash point would approach Jet A in performance in a crash or in-flight fire C K D

**A76-36602** Jet fuel in Canadian operations L Gardner and R B Whyte (National Research Council, Ottawa, Canada) *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760528* 9 p 23 refs

The use of aviation turbine fuel in Canadian operations has been the subject of a study designed to cover all aspects of aircraft operation from ground handling to flight and included such parameters as availability and operating costs. Of particular importance was the effect of Canadian climatic conditions on the requirements for aviation turbine fuels for northern operations. The final conclusions of the study consider that due to the climatic conditions, there is a place for both wide-cut and kerosene fuels in Canadian operations (Author)

**A76-36603 \*** Fuel conservative propulsion concepts for future air transports D E Gray and J W Witherspoon (United Technologies Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.) *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760535* 11 p 10 refs NASA sponsored research

The results of a feasibility study of proposed fuel conservative propulsion concepts for air transports with an assumed Mach 0.8 cruise capability are summarized. All engines considered are based on projected 1985 technology. Operating fuel requirements, propulsion operating costs, and noise characteristics are compared with those of a present technology turbofan engine. The study indicates that an

advanced Brayton cycle gas generator in a turbofan engine or geared to an advanced multibladed, small diameter propeller with a projected efficiency of 80% at Mach 0.8 offers the greatest potential for energy conservation C K D

**A76-36604** **Alternative concepts for advanced energy conservative transport engines** R Hirschkron and R E Neitzel (General Electric Co., Fairfield, Conn.) *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760536* 15 p

The projected fuel consumption characteristics of three unconventional engine design concepts were compared with those of a conventional advanced direct drive turbofan for long range transports designed to cruise at a flight Mach number of 0.8. All engines considered were based on technology compatible with entry into service in the mid to late 1980s. Regeneration and other cycles involving heat exchangers did not offer fuel advantages over the conventional design due to size and weight considerations. Geared turbofans and turboprop engines based on projected improvements in propeller efficiency to the 80% range for Mach 0.8 high disk loading designs showed potential for significant improvements in specific fuel consumption C K D

**A76-36605** **Fuel conservative potential for the use of turboprop powerplants** R L Foss and J P Hopkins (Lockheed California Co., Burbank, Calif.) *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760537* 15 p 6 refs

The turboprop propulsion system may offer the air transportation industry one of the most significant means of achieving reduced operating costs through large reductions in fuel consumption. The prop-fan high speed propeller concept allows the superior propulsive efficiency exhibited by the turboprop to be extended to cruise speeds compatible with current turbofan aircraft. Comparison of a prop-fan and a turbofan powered aircraft, each designed on an equal technology, equal mission and equal comfort basis is used to illustrate the prop-fan benefits. Accountability for the differences in the installation requirements of each propulsion system is included. The significant fuel and cost improvements shown for the prop-fan aircraft call for an extensive research program to verify the performance of this propulsion concept and to provide a data base that will allow incorporation in future aircraft (Author)

**A76-36606** **Aircraft propulsion - A key to fuel conservation. An aircraft manufacturer's view** J A Stern (Douglas Aircraft Co., Long Beach, Calif.) *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760538* 18 p

A range of possible approaches to fuel conservation is examined. The fuel contribution to direct operating costs, aircraft operations and maneuvers designed to conserve fuel, aircraft design variants, modifications, and refittings capable of aiding fuel conservation are discussed. Advantages of turbofan and turboprop derivatives of basic aircraft designs are examined. The RECAT (Reducing Energy Consumption of Commercial Air Transportation) program is outlined. The possible impact of recent technological advances in aircraft design (supercritical airfoils, optimized wing geometry, longitudinal stability augmentation, composites, new metallic structures) on fuel conservation is examined R D V

**A76-36607** **YC-14 status report** J J Foody (Boeing Aerospace Co., Seattle, Wash.) *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760539* 16 p

The status of the YC-14 program is described in this paper in two respects: (1) progress of the design, development and manufacture of the flight articles, and (2) progress that components of the YC-14 make relative to current goals of the aircraft industry. Technology areas where the YC-14 has made distinct contributions are described and indications are given as to the relative contribution

and the remaining potential for development. Such areas include low speed aerodynamic development, fuel conservative design, flight controls technology, and design to cost techniques. In all cases, criteria for incorporation were based not only on technological merit but also on the requirement of minimum life cycle cost. These elements have been incorporated in an operationally capable aircraft that is concluding its manufacturing phase on schedule and is about to begin its flight test program (Author)

**A76-36608** **Status review - YC-15 advanced medium STOL prototype** E R Heald (Douglas Aircraft Co., Long Beach, Calif.) *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760540* 10 p

Program status, design changes, progress in flight testing, supercritical airfoil performance, high lift performance, operation of aircraft systems (stability and control augmentation, externally blown flaps, thrust reversers, wing box), and flight test results for the YC-15 advanced medium STOL prototype are reviewed. The EBF system is designed to enable routine operations into and out of 2000 ft landing strips. Design changes have been introduced in the overall format and wing format. Prototyping experience is reviewed. Some alterations in flap structure to cope with stress and fatigue are noted R D V

**A76-36609** **Airport jet fuel handling and quality control** L C Quigg (Lockheed Air Terminal, Inc., Burbank, Calif.) and J K Siddons (American Airlines, Inc., New York, N Y.) *Society of Automotive Engineers, Air Transportation Meeting, New York, N Y, May 18-20, 1976, Paper 760542* 37 p 18 refs

The ability to handle large volumes of jet fuel at a modern airport and maintain a high degree of purity requires an integrated Quality Control program. The adverse effects of contaminants on the aircraft systems are described to show the need for planned monitoring of the fuel handling systems. Methods for detecting the various fuel contaminants are described along with the effects of the contaminants on dispensing equipment and storage facilities. Methods for removing and eliminating contaminants and the equipment needed are described. The paper shows how only clean, water-free fuel can be delivered to the aircraft (Author)

**A76-36666 #** **Study of the properties of Pd-zeolite-containing hydrogenation catalyst of aromatic hydrocarbons in the presence of sulfur** (Issledovanie svoystv Pd-tseolitsoderzhashchego katalizatora gidrirovaniia aromaticheskikh uglevodorodov v prisutstvii sery) A V Agafonov, V Ia Kruglikov, M V Landau, E D Radchenko, N V Goncharova, O D Konoval'chikov, D F Poezd, V P Svirina, and M V Maikova (Vsesoiuznyi Nauchno-Issledovatel'skii Institut po Pererabotke Nefti i Gaza i Poluchenii Iskusstvennogo Zhidkogo Topliva, Moscow, USSR) *Khimia i Tekhnologiya Topliva i Masel*, no 6, 1976, p 12-14 9 refs. In Russian

**A76-36667 #** **Investigation of the fuel fractions of gas condensates from gas fields in Central Asia** (Issledovanie toplivnykh fraktsii gazovykh kondensatov mestorozhdenii srednei Azii) R B Alieva, E P Seregin, F B Akhundova, G B Skovorodin, and E A Mirbagirova *Khimia i Tekhnologiya Topliva i Masel*, no 6, 1976, p 21, 22. In Russian

Stable sulfur-free gas condensates from several gas fields in Central Asia were studied with a view toward their usefulness in the production of jet fuels. The data indicate that the 130 to 230 C fraction obtained from a mixture of these condensates is suitable as a component of the RT jet fuel, without recourse to dehydration processes V P

**A76-36669 #** **Modern methods of evaluating the properties of jet fuels** (Sovremennyye metody otsenki svoystv reaktivnykh topliv) Z A Sablina, G B Shirokova, T I Ermakova, and V P



Lazarenko Khimia i Tekhnologiya Topliv i Masel, no 6, 1976, p 58-60 6 refs In Russian

The United States ASTM standards and British IP standards for petroleum and its products are reviewed, with particular reference to the standards ASTM 1319, IP 156, ASTM 2386, IP 16, ASTM 1660, IP 197, ASTM 974, IP 139, ASTM 2276, IP 216, ASTM 873, IP 138, ASTM 2551, IP 7, and ASTM 611, IP 2 These, and some other standards, are compared with the German (DIN) and Soviet (GOST) standards V P

**A76-36692** A mathematical model of aircraft for the investigation of nonstationary aerodynamic characteristics S M Belotserkovskii (Prikladnaia Matematika i Mekhanika, vol 39, Sept Oct 1975, p 934 941) PMM - Journal of Applied Mathematics and Mechanics, vol 39, no 5, 1975, p 899 906 Translation

A digital computer model for calculating the linear unsteady aerodynamic characteristics (loads, normal forces, moments) of a flight vehicle is described The schematic model of the aircraft is represented with the aid of a system of planar base elements The general linear unsteady problem of aerodynamics and hydrodynamics is reduced to a combination of canonical epsilon sub j problems, each of which is solved separately Convolution-type integral relations are obtained which permit one to express the aerodynamic characteristics through corresponding transfer functions and laws for the variation of the kinematic parameters with time, epsilon sub j(t) Various theorems concerning the modeling of the aerodynamic characteristics are considered, including the momentum theorem, theorems on the aerodynamic generating function with and without a point, the mean value theorem, and the reversibility theorem B J

**A76-36815** On extreme length flight paths M S Klamkin (Waterloo, University, Waterloo, Ontario, Canada) SIAM Review, vol 18, July 1976, p 486 488

The author solves the following problem An airplane flying with a speed  $v$  with respect to the ground is required to fly for a given length of time  $T$  in a bounded three-dimensional irrotational wind field  $W$  If it is also required to start and finish at the same point, what is the longest path (total arc length) that it can complete, assuming the path is continuous with piecewise continuous first derivatives It is shown that paths arbitrarily close to an upper limit on the path length can be achieved by flying in an arbitrarily small closed path around a point where the wind speed is least and in a plane perpendicular to the wind vector at this minimum point The path of minimum length is achieved by flying back and forth along an arbitrarily small segment containing a point where the wind speed is a maximum and whose direction is parallel to the wind vector at this maximum P T H

**A76-36825 \*** Parametric analysis of advanced technology applied to a single engine trainer E T Schairer and T L Galloway (NASA, Ames Research Center, Moffett Field, Calif) Society of Automotive Engineers, Business Aircraft Meeting, Wichita, Kan, Apr 6-9, 1976, Paper 760459 11 p 8 refs

The potential of applying advanced technology to a single engine trainer configuration is investigated The analysis is performed in a parametric manner to evaluate the individual and combined effects of various aerodynamic and propulsion technology considerations The analysis is accomplished using a computerized aircraft synthesis model that simulates the aircraft design and mission The resulting performance characteristics are compared with a current trainer design to identify the performance improvements or penalties (Author)

**A76-36876 #** The scientific-technical progress as the main intensifying factor at Interflug (Wissenschaftlich-technischer Fortschritt - Hauptsachlicher Intensivierungsfaktor bei der Interflug) J Grenzdoerfer (Gesellschaft fur internationalen Flugverkehr mbH, Berlin, East Germany) Technisch-ökonomische Information der

zivilen Luftfahrt, vol 12, no 2, 1976, p 65 72 In German

The objectives concerning the scientific technical progress for the time period from 1976 to 1980 are examined and a description is given of the results obtained in scientific technical projects related to an intensification of the reproduction process in 1975 Attention is given to improvements regarding the efficiency of airliner maintenance procedures and an increase in the utilization of aircraft in agricultural applications and forest management operations The aims of the scientific technical development plan for 1976 are also discussed G R

**A76-36877 #** The characteristics of flight mechanics in the case of the aircraft Tu-134A (Flugmechanische Besonderheiten des Flugzeuges Tu-134A) T Ligm (Grazhdanskia Aviatsia, no 2, 1975) Technisch-ökonomische Information der zivilen Luftfahrt, vol 12, no 2, 1976, p 75 78, 103 In German

The successful operation of the short haul jet airliner Tu-134 in the USSR and other socialist countries led to the development of the model Tu 134A The new aircraft model uses D 30 engines of the second series with thrust reversal devices, a compressed-air starting system, and an improved fuel control system Relations between flight altitude, the range of the aircraft, cruising speed, and payload are examined and a description is given of the operational characteristics of the aircraft for takeoff, climb, approach, and landing Attention is also given to experiments which were conducted to study the effect of ice formation on the forces to which the aircraft is subjected G R

**A76-36881 ;** The Dolphin airship with undulating propulsion - The maneuverability of a large whirling arm model (Delphinluftschiff mit Wellantrieb - Manovrierfähigkeit eines grossen Rundlaufmodells) W Schmidt (Kammer der Technik, Dresden, East Germany) Technisch-ökonomische Information der zivilen Luftfahrt, vol 12, no 2, 1976, p 104 108 10 refs In German

A model of the Dolphin airship with undulating propulsion was built to demonstrate the correctness of the theoretical predictions which had been made concerning the characteristics of such an airship The model has a length of 5 m and a width of 4 m It can move forwards, backwards, and in a vertical direction upwards and downwards The maneuverability of the model is obtained by a suitable adjustment of the blades of the propulsion device The design of the model is described and photographs which were taken during the maneuverability tests are presented G R

**A76-36882 #** Aerodynamic analysis of different flight attitudes of conventional aircraft XVII (Flugmechanische Analyse verschiedener Flugzustände konventioneller Flugzeuge XVII) F Seidler (Dresden, Hochschule fur Verkehrswesen, Dresden, East Germany) Technisch-ökonomische Information der zivilen Luftfahrt, vol 12, no 2, 1976, p 109 123 In German

The concept of compressibility is considered along with the compressibility characteristics of the air The conditions for which the compressibility of the air can be disregarded are investigated and the significance of the Mach number is discussed Aerodynamic force coefficients in the case of large Mach numbers and a pure supersonic flow are studied, taking into account the pressure distribution at the wing profile, the lift coefficient, and the drag coefficient Attention is also given to aerodynamic force coefficients in the case of large Mach numbers and a mixed subsonic and supersonic flow G R

**A76-36898** Performance measurement Time for a change J H H Grover (Transport Analysis Services) Flight International, vol 110, July 3, 1976, p 7 9

Current United Kingdom take off performance requirements are summarized, and possible reforms are suggested Primary attention is given to factors taken into consideration in determining the decision point (the point at which a captain must decide whether to continue or abandon a take off in the event of an engine failure) and its associated speed  $V_1$ , for a given aircraft taking off with a given

runway configuration. It is suggested that if an aircraft has demonstrated acceptable asymmetric control qualities at low speeds using all means of maintaining directional control, excess runway distances could be converted into a speed,  $V_{go}$  which would indicate the first point on the runway from which the take off could be continued in the event of engine failure. This information plus an indication of the distance along the runway at the time of failure, would provide the basis for prompt and correct pilot action. Operations from largely unrestrictive runways could be carried out at maximum efficiency if the last possible abort point were known.

C K D

**A76-36901 Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex., June 7-9, 1976, Proceedings** Conference sponsored by the American Institute of Aeronautics and Astronautics, New York, American Institute of Aeronautics and Astronautics, Inc., 1976, 236 p.

Papers are presented on jump phenomena in roll-coupled maneuvers of aircraft, nonoptimality of steady-state cruise for aircraft, estimation of the stochastic control of an aircraft flying in atmospheric turbulence, and the stall/spin characteristics of fighter aircraft. Also examined are an aerodynamic parameter identification for the A7 aircraft at high angles of attack, determination of tail off aircraft parameters using systems identification, and the effects of aircraft design and atmospheric turbulence on handling and ride qualities. Ablation induced roll torques on reentry vehicles, Space Shuttle Orbiter entry guidance and control system sensitivity, and an automated scheme to determine design parameters for a recoverable reentry vehicle are also considered.

B J

**A76-36902 \* # Prediction of jump phenomena in roll-coupled maneuvers of airplanes** A A Schy and M E Hannah (NASA, Langley Research Center, Hampton, Va.) In *Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex., June 7-9, 1976, Proceedings* New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p. 1-10, 7 refs.

An easily computerized analytical method is developed for identifying critical airplane maneuvers in which nonlinear rotational coupling effects may cause sudden jumps in the response to pilot's control inputs. Fifth and ninth degree polynomials for predicting multiple pseudo-steady states of roll coupled maneuvers are derived. The program calculates the pseudo-steady solutions and their stability. The occurrence of jump like responses for several airplanes and a variety of maneuvers is shown to correlate well with the appearance of multiple stable solutions for critical control combinations. The analysis is extended to include aerodynamics nonlinear in angle of attack.

(Author)

**A76-36903 \* # Calculation of differential-turning barrier surfaces** H J Kelley and L Lefton (Analytical Mechanics Associates, Inc., Jericho, N.Y.) In *Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex., June 7-9, 1976, Proceedings*

New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p. 11-18, 6 refs. Contract No. NAS2-8738.

The computation of composite differential turn trajectory pairs is studied for 'fast evader' and 'neutral-evader' idealizations introduced in earlier publications. Transversality and generalized corner conditions are examined and the joining of trajectory segments discussed. A criterion is given for the screening of 'tandem-motion' trajectory segments. Main focus is upon the computation of barrier surfaces. Fortunately, from a computational viewpoint, the trajectory pairs defining these surfaces need not be calculated completely, the final subarc of multiple-subarc pairs not being required. Some calculations for pairs of example aircraft are presented.

(Author)

**A76-36904 # Non-optimality of the steady-state cruise for aircraft** J L Speyer (Charles Stark Draper Laboratory, Inc.,

Cambridge, Mass.) In *Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex., June 7-9, 1976, Proceedings*

New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p. 19-25, 11 refs.

For a fairly general aircraft model and a large class of drag models, steady-state cruise for a long time span is nonoptimal with respect to fuel economy. This is proved by a second order variational analysis, using a frequency-domain version of the classical Jacobi (conjugate point) optimality condition. The variational analysis suggests a sinusoidal perturbation away from steady state cruise which improves fuel economy (as confirmed numerically) but is still not optimal. The form of the optimal trajectory for long duration cruise is unknown. However, two intuitive reasons for improved fuel economy using cyclic cruise paths are given.

(Author)

**A76-36905 \* # Estimation of characteristics and stochastic control of an aircraft flying in atmospheric turbulence** K W Iliff (NASA, Flight Research Center, Edwards, Calif.) In *Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex., June 7-9, 1976, Proceedings* New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p. 26-38, 9 refs.

An adaptive control technique to improve the flying qualities of an aircraft in turbulence was investigated. The approach taken was to obtain maximum likelihood estimates of the unknown coefficients of the aircraft system and then, using these estimates along with the separation principle, to define the stochastic optimal control. The maximum likelihood estimation technique that accounted for the effects of turbulence provided good estimates of the unknown coefficients and of the turbulence. The assessment of the stochastic optimal control based on the maximum likelihood estimates showed that the desired effects were attained for the regulator problem of minimizing pitch angle and the tracking problem of requiring normal acceleration to follow the pilot input.

(Author)

**A76-36906 \* # Zoom climb altitude maximization of the F-4C and F-15 aircraft for stratospheric sampling missions** D S Hague, A W Merz (Aerophysics Research Corp.), and W A Page (NASA, Ames Research Center, Stratospheric Projects Office, Moffett Field, Calif.) In *Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex., June 7-9, 1976, Proceedings*

New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p. 39-46, 5 refs.

Some predictions indicate that byproducts of aerosol containers may lead to a modification of the ultraviolet radiation shielding properties of the upper atmosphere. NASA currently monitors atmospheric properties to 70,000 feet using U2 aircraft. Testing is needed at about 100,000 feet for adequate monitoring of possible aerosol contaminants during the next decade. To study this problem the F4C and F15 aircraft were analyzed to determine their maximum altitude ability in zoom-climb maneuvers. These trajectories must satisfy realistic dynamic pressure and Mach number constraints. Maximum altitudes obtained for the F4C are above 90,000 feet, and for the F15 above 100,000 feet. Sensitivities of the zoom-climb altitudes were found with respect to several variables including vehicle thrust, initial weight, stratospheric winds and the constraints. A final decision on aircraft selection must be based on mission modification costs and operational considerations balanced against their respective zoom altitude performance capabilities.

(Author)

**A76-36907 \* Remotely piloted research vehicle evaluation of advanced control system effects on spins** K L Petersen (NASA Flight Research Center, Edwards, Calif.) In *Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex., June 7-9, 1976, Proceedings* New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p. 55-64.

Special functions of an advanced control system were investigated for effects on spin entries and recoveries utilizing a 3/8 scale model of the F15 airplane as a remotely piloted research vehicle.

(RPRV) Telemetry uplinks and downlinks were used with a ground based digital computer to mechanize the RPRV control system for spin tests in flight. Results from the model RPRV flight tests and from a real time digital spin simulation were used to evaluate the F 15 stall inhibitor and an automatic spin recovery system developed for the RPRV model (Author)

**A76-36908 \* #** Propulsive-lift concepts for improved low-speed performance of supersonic cruise arrow-wing configurations P L Coe, Jr (NASA, Langley Research Center, Hampton, Va) In Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex., June 7-9, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 65-69 5 refs

Low-aspect ratio highly swept arrow-wing supersonic aircraft possess high levels of aerodynamic efficiency at supersonic cruising speeds, however, their inherently poor low speed lift characteristics require design constraints that compromise supersonic performance. The data discussed in this paper were obtained in wind tunnel tests with supersonic crusing configurations, in which propulsive lift concepts were used to improve low-speed performance. The data show that the increased low-speed lift provided by propulsive lift permits reduction of both wing size and installed thrust. This yields a better engine/airframe match for improved supersonic cruise efficiency and range, while still providing acceptable take-off field lengths V P

**A76 36909 #** Dynamic stall reconsiderations L E Ericsson and J P Reding (Lockheed Missiles and Space Co., Inc., Sunnyvale, Calif) In Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex., June 7-9, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 70-78 24 refs

Dynamic airfoil stall is characterized by two separate events (1) there is a substantial overshoot of the static stall angle and static lift maximum before bonafide separations occurs, (2) after separation has occurred a 'spilled' leading edge vortex travels downstream over the chord causing large changes in the aerodynamic force distribution. With some license the first event can be characterized as quasi-steady, whereas the second event is truly a transient phenomenon. In earlier work only the quasi steady phase of dynamic stall was considered. A new look has been taken at the dynamic stall phenomenon to see if the transient phase can be included without destroying the simplicity of the original analysis. The present paper describes how the transient effect of the 'spilled' leading edge vortex can be described by simple analytic means (Author)

**A76-36910 \* #** Recent research related to prediction of stall/spin characteristics of fighter aircraft L T Nguyen, E L Anglin, and W P Gilbert (NASA, Langley Research Center, Hampton, Va) In Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex., June 7-9, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc., 1976 p 79-91 13 refs

The NASA Langley Research Center is currently engaged in a stall/spin research program to provide the fundamental information and design guidelines required to predict the stall/spin characteristics of fighter aircraft. The prediction methods under study include theoretical spin prediction techniques and piloted simulation studies. The paper discusses the overall status of theoretical techniques including (1) input data requirements, (2) math model requirements, and (3) correlation between theoretical and experimental results. The Langley Differential Maneuvering Simulator (DMS) facility has been used to evaluate the spin susceptibility of several current fighters during typical air combat maneuvers and to develop and evaluate the effectiveness of automatic departure/spin prevention concepts. The evaluation procedure is described and some of the more significant results of the studies are presented (Author)

**A76-36911** An experimental investigation of favorable interference effects from a wing and propotor S L Griffith, F R DeJarnette (North Carolina State University, Raleigh, N C), and J J Murray (U S Army, Research Office Research Triangle Park, N C) In Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex., June 7-9, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 92-100 11 refs Grants No DAHC04 74 G 0007, No DAHC04-75 G 0023

An experimental investigation was conducted in a subsonic wind tunnel to determine the interference effects of a propotor and a wing on their lift and drag characteristics. It was theorized that the oncoming stream would sweep the wake of the propotor over the top of the wing, resulting in favorable interference effects. To test this theory, a wing was mounted in the test section of the wind tunnel and a propotor was positioned above the wing on a shaft through the ceiling of the test section. Lift and drag forces were measured on the wing, and axial loads on the propotor, for test-section velocities from 0 to 60 ft/sec and propotor shaft speeds from 0 to 500 rpm. Test conditions varied the wing angle of attack and propotor tilt angle, position, and shaft speed. The results showed significant increases in lift and decreases in drag for both the wing and propotor due to favorable interference near the stall angle of attack of the wing. Below the stall, favorable interference effects were small. More favorable results were obtained for the propotor shaft tilted forward to about 10 deg, while unfavorable results were found for a tilt angle of 22.8 deg and negative tilt angles. The propotor shaft speed and height above the wing had a significant effect on the results, while the chord-wise position was insignificant (Author)

**A76-36912 \* #** Flight test design for efficient extraction of aircraft parameters W R Wells and S Ramachandran (Cincinnati, University, Cincinnati, Ohio) In Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex., June 7-9, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 101-107 9 refs Grant No NGR-36-004 061

This paper considers the design of flight control inputs which result in a minimization of the nonuniqueness problem of parameter identification due to statistical correlation. The performance index for the control design is taken as a linear weighted sum of the squares of the correlation coefficients of the aerodynamic stability and control derivatives as computed from the Cramer-Rao lower bound matrix. An optimal input design is demonstrated for an F 8 aircraft with supercritical wing. Reduced correlations are noted and corresponding estimates and confidence levels presented (Author)

**A76-36913 #** Aerodynamic parameter identification for the A-7 airplane at high angles of attack D E McBrinn and B B Brassell (Vought Corp., Dallas, Tex) In Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex., June 7-9, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 108-117

Methods are developed for the practical determination of aircraft stability coefficients from flight test data at nonlinear flight regimes. The emphasis throughout is on development of practical techniques for everyday use. Modeling is performed by step up/step down regression analysis. Kalman filter techniques are used for data preprocessing. Parameter identification is by quasi linearization techniques, extended to embrace multiple maneuvers and nonlinear plants. The techniques developed are applied to actual flight test data for the A 7 aircraft. This produces a model which is then tested by using it to predict the dynamics of a maneuver which was not used in the analyses. The results validate the usefulness of the techniques (Author)

**A76-36914 #** Motion analysis procedure for asymmetric vehicles C J Welsh and W R Lawrence (ARO, Inc., Arnold Engineering Development Center, Arnold Air Force Station, Tenn) In Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex.,

June 7-9, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 118-127 8 refs

The paper discusses a recently developed procedure for the analysis of free flight motion to determine the aerodynamic coefficients of a vehicle having appreciable aerodynamic and inertia asymmetries. The primary problem in handling a vehicle with an appreciable asymmetry is related to defining expressions for the aerodynamic forces and moments involved. These forces and moments can be very dependent on the roll orientation of the vehicle relative to the plane of the total yaw angle. Aerodynamic data obtained by using this procedure in aeroballistic range tests of elliptic cross section bodies indicate the potential usefulness of the developed procedure. (Author)

**A76-36915** Determination of tail-off aircraft parameters using systems identification G D Park (Gates Learjet Corp., Wichita, Kan.) In Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex., June 7-9, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 128-136 10 refs

Tail-off parameters were extracted from in flight response data utilizing a systems identification computer program developed by NASA. The response data included aircraft responses as well as empennage structural responses. Using the parameters extracted from these two types of responses, tail-off parameters were determined. Comparisons are presented of these parameters with wind tunnel test results. In addition to the tail-off parameters, pilot control force parameters were also determined. (Author)

**A76-36916 \* #** Maximum likelihood estimates of lift and drag characteristics obtained from dynamic aircraft maneuvers K W Iliff (NASA, Flight Research Center, Edwards, Calif.) In Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex., June 7-9, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 137-150

A maximum likelihood estimation method for obtaining lift and drag characteristics from dynamic flight maneuvers was investigated. This paper describes the method and compares the estimates of lift and drag obtained by using the method with estimates obtained from wind-tunnel tests and from established methods for obtaining estimates from flight data. In general, the lift and drag coefficients extracted from dynamic flight maneuvers by the maximum likelihood estimation technique are in good agreement with the estimates obtained from the wind-tunnel tests and the other methods. When maneuvers that met the requirements of both flight methods were analyzed, the results of each method were nearly the same. The maximum likelihood estimation technique showed promise in terms of estimating lift and drag characteristics from dynamic flight maneuvers. Further studies should be made to assess the best mathematical model and the most desirable type of dynamic maneuver to get the highest quality results from this technique. (Author)

**A76-36921 #** A study of the effects of high lateral/directional feedback gains at moderate angles of attack G W Hillman (Vought Corp., Dallas, Tex.) In Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex., June 7-9, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 183-191 Contract No. N00019-74-A-0376

A stall/departure prevention system having unusually high lateral/directional feedback gains was once proposed for the A-7 airplane. The effects of high gains on flying qualities at moderate angles of attack were studied by comparing the A-7's basic flying qualities with those that would result from installation of the departure prevention system. It was found that the high gains are beneficial in some respects and can be accepted by pilots. The high gains did not significantly change the predicted flying qualities. Three pilots, who evaluated the high gain system in simulated

air to ground tracking and in simulated carrier landings, found that flying qualities were satisfactory and not significantly changed from the basic system. Statistical analyses of their simulator runs corroborate their evaluation and show some small benefits from high gains at moderate angles of attack. (Author)

**A76-36922 \* #** Flight investigation of the response of a helicopter to the trailing vortex of a fixed-wing aircraft W R Mantay, G T Holbrook, R L Campbell, and R L Tomaine (NASA, Langley Research Center, Hampton, Va.) In Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex., June 7-9, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 192-200 7 refs

A flight investigation was conducted to quantitatively determine the response of a medium weight helicopter to the trailing vortex system of a fixed-wing aircraft. Flight tests and analytical tools were both utilized in the investigation. The flight tests involved an extensively instrumented UH-1H helicopter and a C-54 aircraft. Penetrations of the vortex system by the UH-1H were made at the following nominal conditions: the C-54 flew at 5500 feet altitude at a nominal gross weight of 58,000 pounds and an indicated airspeed of 115 knots in a cruise configuration. The UH-1H, nominally 7200 pounds gross weight, flew at 60 knots indicated airspeed during the penetrations at separation distances of 6.64 nautical miles to 0.42 nautical mile between aircraft. In general, the data analyzed for the above tests indicated that no unsafe penetration occurred. Further, penetrating vehicle attitude changes and structural loads were nominal. In addition, the response of the helicopter did not change appreciably with decreased separation distance. (Author)

**A76-36923 \* #** Hazard criteria for wake vortex encounters R I Sammonds, G W Stinnett, Jr (NASA, Ames Research Center, Moffett Field, Calif.), and W E Larsen (FAA, Washington, D C.) In Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex., June 7-9, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 201-209 15 refs

Piloted six degrees-of-freedom motion simulator investigations were conducted at the NASA Ames Research Center to determine criteria relating the hazard posed by a wake vortex encounter to the response of the encountering airplane. These investigations demonstrated that wake vortex encounters can be realistically reproduced on a simulator, established that the maximum bank angle due to the encounter provides the best correlation with the pilot's subjective assessment of the hazard, and determined hazard boundaries in terms of maximum bank angle for two classes of jet transport aircraft. (Author)

**A76-36924 \* #** The effects of aircraft design and atmospheric turbulence on handling and ride qualities C R Jones (USAF, Ballistics Re Entry Vehicle Div., Los Angeles Air Force Station, Calif.) and I D Jacobson (Virginia University, Charlottesville, Va.) In Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex., June 7-9, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 210-219 23 refs Grant No. NGR 47-005-208

The effects of aircraft dynamic characteristics on passenger ride quality were investigated to determine ride-quality isocontours similar to aircraft handling-qualities contours. Measurements were made on a motion base simulator while varying the aircraft short-period and Dutch Roll frequencies and dampings. Both pilot ratings and subjective ride quality ratings were obtained during simulator flight. Ride and handling qualities were found to be complimentary for the Dutch Roll mode, but not for the short-period mode. Regions of optimal ride and handling qualities were defined for the short period mode, and the effects of changes in turbulence level studied using mathematical models. (Author)

**A76-36925 \* #** Study of an aircraft decoupled longitudinal control system for approach and landing G K Miller, Jr (NASA, Langley Research Center, Hampton, Va) In Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex, June 7-9, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 220-227 8 refs

A series of ground-based and in-flight simulation studies of the application of steady state decoupled longitudinal controls to a short take-off and landing (STOL) transport have been made. The externally blown flap STOL was selected for study because it was considered to be a worst case situation from the control viewpoint. The decoupled longitudinal control system used constant prefilter and feedback gains to provide independent control of flight-path angle, pitch angle, and forward velocity during landing approach. The decoupled controls were compared to a more conventional stability augmentation system. The pilots were enthusiastic about the decoupled controls, the pilot workload was reduced and the landing performance significantly improved. The benefit of the decoupled controls was more dramatic during in-flight simulation using a variable stability airplane than was the case with either fixed or moving base, ground-based simulators (Author)

**A76-36926 \* #** An analytical method for ride quality of flexible airplanes R L Swaim, D K Schmidt (Purdue University, West Lafayette, Ind), P A Roberts (USAF, Washington, D C), and A J Hinsdale In Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex, June 7-9, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 228-232 7 refs Grant No. NsG 4003

A new and easily used state variable method of aircraft ride quality analysis is developed and its use is illustrated by a numerical example using DC 8 airplane equations of motion. The method readily allows any type of stability augmentation system to be included for good handling qualities. As part of the ride quality analysis, a particularly powerful method of specifying and achieving all roots of a desired closed-loop characteristic equation by use of full state variable feedback is described and applied to the DC 8 example (Author)

**A76-36987 \* #** A finite element solution of unsteady transonic flow problems for three-dimensional wings and bodies K R Kimble (Tennessee, University, Tullahoma, Tenn) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif, July 14-16, 1976, Paper 76-328* 12 p 10 refs Grant No. NsG 1224

A computerized finite element method has been developed to solve a form of the three-dimensional inviscid, irrotational unsteady transonic equation for pointed and rectangular wings and wing/body combinations. The equation is a 'parabolized' version of the full unsteady transonic equation which includes the effect of the advancing wave and the acceleration in the steady flow field thus including a thickness effect. Automatic mesh generation using conformal mapping has the advantage of allowing relatively arbitrary cross sections to be closely approximated while taking advantage of the body's similarity to a more simple configuration. Plunge, pitch, and roll modes are computed (Author)

**A76-36989 #** Phase plane analysis of transonic flows O Bibrariz (U S Naval Postgraduate School, Monterey, Calif) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif, July 14-16, 1976, Paper 76-332* 8 p 10 refs AF Project 320D

An exact solution to the two dimensional transonic equation is presented, two nonlinear ordinary differential equations, obtained from separation of variables, lead to a phase plane representation which is equivalent to the perturbation velocities. In the phase plane, the parabolic character of transonic flow solutions is evident, the sonic character of the equations is also demonstrated analytically. It is shown, furthermore, that the parameter 1 minus the square of the

free stream Mach number and the shape of the surface govern the most important features of the solution and that other boundary conditions are secondary to these in importance. Some peculiarities of transonic flow are properly described by the present solution, the possibility for predicting the location of normal shocks is surmised (Author)

**A76-36992 #** Turbulent boundary layer surface-pressure fluctuation near an airfoil trailing edge M Hahn (Boeing Commercial Airplane Co., Seattle, Wash) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif, July 14-16, 1976, Paper 76-335* 9 p 21 refs Research sponsored by the Boeing Independent Research and Development Program

Surface pressure fluctuations beneath a subsonic turbulent boundary layer were measured with an array of closely spaced, flush-mounted transducers. The measurements were made immediately upstream of the trailing edge of an airfoil. The streamwise extent of the measured area was of the order of the boundary layer thickness of the trailing edge. Momentum thickness Reynolds numbers ranged from 10,000 to 47,000. Spectral densities were digitally analyzed. The streamwise cross spectra are of a broadband bump type in contrast to the monotonic decay of Corcos' theoretical spectra except for small separation distance and for the low frequency range. The present paper discusses the observed pressure fluctuation in the light of the existing theories of the structure of turbulent boundary-layer flow (Author)

**A76-36994 \* #** A numerical study of viscous flow around an airfoil J C Wu and S Sampath (Georgia Institute of Technology, Atlanta, Ga) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif, July 14-16, 1976, Paper 76-337* 13 p 16 refs Grants No. NsG-1004, No. DAHC04 75 G 0147

An integrodifferential method, previously formulated in terms of velocity and vorticity vectors, is reformulated in terms of stream function and vorticity for two dimensional incompressible viscous flows. The reformulated integrodifferential method is shown to retain the distinguishing feature of the previous formulation in permitting the confinement of the solution field to the viscous region of the flow and consequently offers great computational advantages. The application of this procedure in a study of an incompressible flow around an impulsively started 9% thick symmetric Joukowski airfoil at an angle of attack of 15 deg and a Reynolds number of 1000 is discussed. Numerical results are presented and compared with available finite difference results (Author)

**A76-37006 #** The blunt body problem in nonuniform flow field T C Lin, B L Reeves, D C Howy and D Siegelman (Avco Corp., Avco Systems Div., Wilmington, Mass) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif, July 14-16, 1976, Paper 76-354* 18 p 23 refs Contracts No. F04701 72-C-0150, No. F04701-74 C-0208

An investigation has been made to study the influence of a nonuniform freestream on blunt body flow fields. Two different classes of shear flows are considered here, i.e. jet and wake flows. The blunt body inviscid flow and boundary layer structure with real gas properties are examined. Results based on a Navier Stokes model are also reported. Numerical results indicate that the freestream nonuniformity can significantly alter the blunt body flow properties. The physical implication of this flow nonuniformity upon ground test data interpretation, flow instability and heating augmentation in debris erosion environments and pulsating flow on indented nosetips is discussed. Comparison of numerical results with available experimental data are given (Author)

**A76-37007 #** Interference heating due to shock wave impingement on laminar and turbulent boundary layers F T Hung, S N Greenschlag, and C A Scottoline (Rockwell International Corp.,

Space Div., Downey, Calif.) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976, Paper 76-355* 10 p 15 refs

A simple method is developed to predict heating to a flat plate surface influenced by an impinging shock wave emanating from a two-dimensional wedge. Once the free stream flow conditions and shock generator wedge angle are specified, peak heating values can be computed for either laminar or turbulent oncoming flow. Flow which is initially laminar can either remain laminar or be tripped to transitional or turbulent flow by the impinging shock wave. A flat plate transition Reynolds number for flow perturbed by the impinging shock wave is also derived from heating correlations. Finally, the study results indicate that the extremely large increases in interference heating over the undisturbed flat plate values are partially due to boundary layer transition caused by the impinging shock wave. Experimental data obtained from simple geometry wedge/flat plate models as well as recent results from Space Shuttle models are used in this analysis. (Author)

**A76-37008 #** **Boundary-layer transition experiments on pre-ablated graphite nosetips in a hyperballistics range.** D. C. Reda and R. A. Leverance (U.S. Navy, Naval Surface Weapons Center, Silver Spring, Md.) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976, Paper 76-356* 20 p 13 refs

An experimental program was conducted to test the validity of extrapolating the PANT (Passive Nostet Technology) boundary layer transition correlation, based on wind tunnel/calorimeter-model results, to actual nosetip materials exposed to actual reentry environments. Pre-ablated ATJ-S graphite nosetips were flown on specific ballistics range trajectories through both air and nitrogen (with and without ablation). Surface temperature contours were measured via electro-optical pyrometry, from which transition zone presence and location were inferred. Significant discrepancies were noted between predicted and experimentally observed transition zone behavior, as influenced by Reynolds number and wall-temperature effects. A question was raised concerning characterization of a surface microroughness distribution, for transition purposes, by its mean value. In addition, significant surface roughness effects on laminar flow heat-transfer rates were noted. (Author)

**A76-37016 #** **Experimental measurements of the turbulent boundary layer on a yawed, spinning slender body.** W. B. Sturek (U.S. Army, Ballistics Research Laboratories, Aberdeen Proving Ground, Md.) and J. E. Danberg (Delaware University, Newark, Del.) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976, Paper 76-365* 8 p 13 refs

Experimental measurements of the tripped turbulent boundary layer profile characteristics on a yawed, spinning tangent-ogive-cylinder model are described. The profile measurements were made using a flattened total head probe at 30-deg increments completely about the azimuthal plane for three longitudinal stations at Mach 3, 4-deg angle of attack, and 10,000 rpm. Wall static pressure measurements were obtained in order to compute velocity profiles from the measured total head pressure. The data have been analyzed according to 'law of the wall law of the wake' concepts using a least squares fitting technique. The effect of azimuthal position is revealed in the growth of the wake parameter by factor of two from the wind to the leeside. A small but consistent effect of spin is also apparent. (Author)

**A76-37019 \* #** **Numerical solution of periodic transonic flow through a fan stage.** J. I. Erdos, E. Alzner (General Applied Science Laboratories, Inc., Westbury, N.Y.), and W. McNally (NASA, Lewis Research Center, Cleveland, Ohio) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976, Paper 76-369* 17 p 17 refs. Contract No. NAS3 16807

A numerical method of solution of the inviscid, compressible,

two-dimensional unsteady flow on a blade-to-blade stream surface through a stage (rotor and stator), or a single blade row, of an axial flow compressor or fan is described. A cyclic procedure has been developed for representation of adjacent blade-to-blade passages, which asymptotically achieves the correct phase between all passages of a stage. A shock capturing finite difference method is employed in the interior of the passage, and a method-of-characteristics technique is used at the boundaries. The blade slipstreams form two of the passage boundaries, and are treated as moving contact surfaces capable of supporting jumps in entropy and tangential velocity. The Kutta condition is imposed by requiring the slipstreams to originate at the trailing edges, which are assumed to be sharp. Results are presented for several transonic fan rotors, and compared with available experimental data consisting of holographic observations of shock structure and pressure contour maps. A subcritical stator solution is also compared with results from a relaxation method. Finally, a periodic solution for a stage consisting of 44 rotor blades and 46 stator blades is discussed. (Author)

**A76-37025 \* #** **Two inviscid computational simulations of separated flow about airfoils.** R. W. Barnwell (NASA, Langley Research Center, Hampton, Va.) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976, Paper 76-379* 9 p 17 refs

Two inviscid computational simulations of separated flow about airfoils are described. The basic computational method is the line relaxation finite-difference method. Viscous separation is approximated with inviscid free streamline separation. The point of separation is specified, and the pressure in the separation region is calculated. In the first simulation, the empiricism of constant pressure in the separation region is employed. This empiricism is easier to implement with the present method than with singularity methods. In the second simulation, acoustic theory is used to determine the pressure in the separation region. The results of both simulations are compared with experiment. (Author)

**A76-37028 \* #** **Implicit finite-difference procedures for the computation of vortex wakes.** J. L. Steger and P. Kutler (NASA, Ames Research Center, Moffett Field, Calif.) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976, Paper 76-385* 13 p 19 refs

Implicit finite difference procedures for the primitive form of the incompressible Navier Stokes and the compressible Euler equations are used to compute vortex wake flows. The partial differential equations in strong conservation law form are transformed to cluster grid points in regions with large changes in vorticity. In addition to clustering, fourth order accurate, spatial difference operators are used to help resolve the flow field gradients. The use of implicit time-differencing permits large time steps to be taken since temporal variations are typically small. Computational efficiency is achieved by approximate factorization. Both two dimensional and preliminary three dimensional calculations are described and qualitatively compared with existing experimental data. (Author)

**A76-37029** **Wind shear program and status.** L. Langweil (FAA, Washington, D.C.) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976, Paper 76-386* 9 p

The wind shear program of the FAA, which is designed to alleviate the hazards of wind shear in the terminal area, is described. The program investigates solutions to wind shear hazards in three categories: (1) through the use of ground based sensors (gust front sensors, vertical probe sensors and glide slope scan sensors); (2) through the use of airborne sensor systems; and (3) by providing localized wind shear forecasts on a terminal by terminal basis. B. J.

**A76-37031** **Some observations of thunderstorm induced low-level wind variations.** R. C. Goff (NOAA, National Severe Storms

Laboratory, Norman, Okla.) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976, Paper 76-388* 8 p 5 refs US Department of Transportation Contract No. FA76WAI-622

The severe thunderstorm with its accompanying phenomena is to be avoided by airborne vehicles. In addition to the precipitating portion of the storm, which is detectable by conventional radar or visual observations, there exists often an outflow region without precipitations. A study of the character of the outflow's leading edge conducted by Goff (1975) is extended to include the complete internal structure of the outflow. A 481 m meteorological tower was employed in the investigations. Attention is given to data sources, aspects of data interpretation, and wind variations in the outflow perturbed boundary layer. It is found that the cold air outflow preceding a thunderstorm contains shear and turbulence zones which may adversely affect an aircraft. G R

**A76-37037** # High-potential clouds in jet-engine exhausts. J F Shaeffer and T C Peng (McDonnell Douglas Research Laboratories, St. Louis, Mo.) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976, Paper 76-397* 8 p 25 refs Contract No. F33615-74-C-3091

Electrostatic probes in the jet engine exhaust sometimes produce current pulses known as spikes. The spike signals which precede jet engine gas-path failures are deduced to be a particular form of negative electrical discharge (corona discharge) referred to as Trichel pulses. A negative corona discharge, however, requires the presence of a positive high potential source or charged cloud. Analyses of spike shower data and known properties of Trichel pulses reveal that the spike signals are induced by a positive high potential cloud which moves past the probe with the exhaust gases. The relationship between charge cloud formation and imminent failure is not yet understood. S D

**A76-37044** # On the design of subsonic airfoils for high lift. R H Liebeck (Douglas Aircraft Co., Long Beach, Calif.) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976, Paper 76-406* 26 p 32 refs. Research sponsored by the McDonnell Douglas Independent Research and Development Program and US Air Force.

A unique approach to subsonic airfoil design has been developed which results in significant performance improvements. For a given set of design conditions including the Reynolds number and Mach number, an optimized pressure distribution is defined, and an inverse potential flow program is used to determine the corresponding airfoil shape. Extension to the multi-element airfoil design problem has been studied, and a restricted set of trial solutions has been obtained. Wind tunnel tests and direct applications have validated the analysis. Example applications include long endurance aircraft, propellers, fans, and race car wings. (Author)

**A76-37051** \* # Summary of some recent studies of subsonic vortex lift and parameters affecting the leading-edge vortex stability. J E Lamar (NASA, Langley Research Center, Hampton, Va.) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976, Paper 76-414* 13 p 16 refs.

Various subsonic configurations which develop vortex lift are examined herein. Comparisons are made with data and the combination of direct and indirect edge forces through use of the suction analogy. For most configurations, the use of the indirect or augmented vortex lift leads to improved agreement with data. The studies conducted showed that it is possible for the leading-edge vortex to exhibit bursting on a cropped wing and the wing aerodynamic characteristics not show the effect. It was further found that the distributions of leading-edge suction correlate well with the

maintenance of vortex flow aerodynamic characteristics. Lastly, a method is presented for relating the initial value of circulation and axial velocity of the leading-edge shed vortex to the wing geometry. (Author)

**A76-37052** \* # Convective merging of vortex cores in lift-generated wakes. V J Rossow (NASA, Ames Research Center, Moffett Field, Calif.) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976, Paper 76-415* 10 p 17 refs.

The several wake vortices which originate from aircraft wingtips, flap edges, engine pylons, etc. usually merge, in the far field, to form a single pair whose structure determines the hazard posed to encountering aircraft. To gain an understanding of the process whereby vortices merge and disperse, a numerical study was made of the interaction of two dimensional, time-dependent, inviscid vortical regions. It was found that discrete boundaries, which depend on the structure and spacing of the vortices, distinguish merging from nonmerging situations. Furthermore, certain arrays of finite vortex cores that alternate in sign were found to undergo division and merging that may be useful in alleviating the hazard posed by aircraft wakes. (Author)

**A76-37053** \* # A new unified approach for analyzing wing-body-tail configurations with control surfaces. K Tseng and L Morino (Boston University, Boston, Mass.) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976, Paper 76-418* 12 p 22 refs. Grant No. NGR 22-004-030.

A general theory for steady and unsteady, subsonic and supersonic potential aerodynamics for complex configurations is presented. Special attention is given to the theoretical formulation and the corresponding numerical implementation for coplanar interfering surfaces. Applying the Green's function method to the equation of the velocity potential and discretizing the spatial problem by using the finite-element technique, yields a set of differential delay equations in time relating the potential to the normal wash. For fully unsteady flow, the motion is assumed to consist of constant subsonic or supersonic speed for time  $t$  less than or equal to 0 (steady state) and of small perturbations around the steady state for time  $t$  greater than 0; the solution is obtained in the Laplace domain. From the potential, the aerodynamic pressure and the generalized forces are evaluated. The program SOUSSA (Steady, Oscillatory and Unsteady Subsonic and Supersonic Aerodynamics) is briefly described. Numerical results obtained with SOUSSA are presented. (Author)

**A76-37158** # An investigation of the free vibration of plates constructed from composite materials using the finite element method (Issledovanie sobstvennykh kolebaniy plastinok, vypolnennykh iz kompozitsionnykh materialov, s pomoshch'yu metoda konechnykh elementov). A S Vol'mir and V A Smetanenko. *Mekhanika Polimerov*, Mar-Apr 1976, p 284-288. 7 refs. In Russian.

The form and frequency of small free vibrations in thin plates made from composite materials are analyzed using the finite element method. The influence of the stiffness characteristics of the material on the free frequency and form of oscillations in planar cantilevered blading in which the inclined edges are fixed is analyzed, and an example of the application of the finite element method to free oscillations of an orthogonal plate in the form of an airfoil is presented. Rectilinear and modified triangular flexible finite elements are used to model a continuous system. The matrix of element masses is constructed on the basis of a four-member polynomial specifying deflection. C K D

**A76-37201** # Prediction of strength in gas turbine engines of long service life (Prognozirovaniye prochnosti GTD bol'shogo resursa). N D Kuznetsov. *(Vsesoiuznaya Nauchno-Tekhnicheskaya Konferentsiya po Konstruktsionnoi Prochnosti Dvigateli, 3rd, Kuibyshev,*

USSR Oct 15 17, 1974) *Problemy Prochnosti*, May 1976, p 3-9 In Russian

The service life and reliability of gas turbine engines designed for prolonged lifetime depend on the static stresses involved, thermal stresses and performance stability of the engine components, overall vibrations and alternating stresses in the components, endurance of parts, and technological reproducibility. The paper outlines the state of the art and fundamental problems regarding the prediction of stability of gas turbine engines of long service life. Differences in the concepts of safe life and state dependent life of engines are clarified. Two major problems are formulated: prediction of safety margin and service life during design and final adjustment, and prediction of engine condition and evaluation of residual life. Measures necessary to ensure prolonged service life in terms of stability are identified and discussed. S D

**A76-37208 #** **Complex of full scale vibration tests of aircraft engines (Kompleks naturnykh vibroispytaniy dvigatelei letatel'nykh apparatov)** D S Elenevskii, R S Bekbulatov, L M Mel'nikov, B A Rogozhin, and I G Sipukhin (*Vsesoiuznaia Nauchno-Tekhnicheskaya Konferentsiya po Konstruktsionnoi Prochnosti Dvigateli, 3rd, Kuibyshev, USSR, Oct 15-17, 1974*) *Problemy Prochnosti*, May 1976, p 37-40 In Russian

The paper examines methodological problems regarding full-scale vibration testing of engines and their different sections: on electro-dynamical rigs under predetermined and random excitation. A complex of full scale vibration tests is described, including power unit, automatic systems for programmed control of excitation, data acquisition systems, and systems for analog and digital processing of test results. The complex has been in service for several years and yielded good results in testing aircraft engines. S D

**A76-37214 #** **Fatigue of gas turbine blades made from cast heat-resistant alloys (Ustalost' lopatok gazovykh turbin iz liteynykh zharoprochnykh splavov)** B F Balashov, A N Petukhov, A N Arkhipov, and B V Volodenko (*Vsesoiuznaia Nauchno-Tekhnicheskaya Konferentsiya po Konstruktsionnoi Prochnosti Dvigateli, 3rd, Kuibyshev, USSR, Oct 15-17, 1974*) *Problemy Prochnosti*, May 1976, p 65-73 10 refs In Russian

Fatigue test results are presented for profile and root sections of gas turbine blades made from cast nickel alloys ZhS6K, ZhS6U, and VZhL12U at normal and elevated temperatures. Particular attention is given to the effect of structural and technological factors on the fatigue of the blades. It is shown that the fatigue of the profile and locking connections of cast blades increases with increasing test temperature. Fatigue strength is greatly affected by the scale factor, where the endurance limit is decreased with an increase in dimensions. Asymmetry of loading cycle and stress concentration have a lesser effect. Statistical characteristics pertaining to the distribution of the endurance limits of blade attachments are presented. S D

**A76-37219 #** **Damping of vibrations in multisupport manifolds (Dempfirovaniye kolebaniy mnogoopornnykh truboprovodov)** N S Kondrashov and L A Lashkova (*Vsesoiuznaia Nauchno-Tekhnicheskaya Konferentsiya po Konstruktsionnoi Prochnosti Dvigateli, 3rd, Kuibyshev, USSR, Oct 15-17, 1974*) *Problemy Prochnosti*, May 1976, p 88-91 In Russian

Forced vibrations in multisupport manifolds of aircraft engines under harmonic and random kinematic excitations are analyzed and a number of design calculations are presented. The stiffness of the supports is represented by a complex form in which the imaginary component of stiffness considers damping at a support. A numerical analysis of the formulated problem allowed formulation of design recommendations for harmonic vibrational loads. The behavior of a manifold under the action of random noise is discussed with emphasis on determining how noise is to be taken into account in the design stage. Two nomograms are obtained which respectively determine the required number of supports from frequency and length and the optimal stiffness of the supports from frequency for different diameters of the manifolds. S D

**A76-37220 #** **A digital measuring system for the registration of unsteady temperature fields (Tsifrovaya izmeritel'naya sistema dlia registratsii nestatsionarnykh temperaturnykh polei)** N A Fot, A G Maliy, Iu A Kolomiets, and M A Selivanov (*Akademiya Nauk Ukrainskoi SSR, Institut Problem Prochnosti, Kiev, Ukrainian SSR*) (*Vsesoiuznaia Nauchno-Tekhnicheskaya Konferentsiya po Konstruktsionnoi Prochnosti Dvigateli, 3rd, Kuibyshev, USSR, Oct 15-17, 1974*) *Problemy Prochnosti*, May 1976, p 92-94 In Russian

A digital system for registering unsteady temperatures from sensor response during investigations of thermal stress in the elements of aircraft gas turbine engines is described. In the proposed system, transformation of the temperature data into digital code takes place simultaneously with its registration on punched tape. The data is presented in a form suitable for further computer processing with the appropriate algorithms. The system can be used in test stands to study a variety of physico-mechanical and strength properties of material samples and construction elements, or to directly measure temperature fields in full-size objects. C K D

**A76-37268 #** **Aerodynamic symmetry of aircraft and guided missiles** P H Zipfel (USAF, Armament Laboratory, Eglin AFB, Fla.) *Journal of Aircraft*, vol 13, July 1976, p 470-475 5 refs

A technique is developed that takes advantage of the inherent configurational symmetries of aircraft and guided missiles to eliminate some force and moment derivatives. Starting with the Principle of Material Indifference, tensor analysis is employed to derive two simple conditions for vanishing aerodynamic derivatives. The results apply to derivatives of arbitrary order, taken with respect to linear and angular velocities, linear accelerations, and control surface deflections. Two charts are presented that sift out the vanishing derivatives up to second order for missiles with tetragonal symmetry, and up to third order for aircraft with reflectional symmetry. (Author)

**A76-37269 #** **Lifespan of trailing vortices in a turbulent atmosphere** S C Crow (Poseidon Research, Los Angeles, Calif.) and E R Bate, Jr. *Journal of Aircraft*, vol 13, July 1976, p 476-482 16 refs. Research supported by Aero Vironment, U.S. Department of Transportation Contract No. TSC 523

The lifespan of aircraft trailing vortices is controlled by a mutual induction instability excited by atmospheric turbulence. The purpose here is to incorporate the effects of turbulence and thereby predict wake lifespan as a function of meteorological conditions. A statistical definition of lifespan is proposed, and the universal function of turbulence intensity is computed for the case when the vortices are too weak to influence their own deformation. Vortex induction then is included, and the universal function is computed in the opposite limit by the method of stationary phase. In that limit, vertical currents are the chief exciters of instability. The paper concludes with a review of a practical method for actively exciting the mutual induction instability. The method would shorten the typical lifespan of a 747 wake by a factor of 3. (Author)

**A76-37270 \*** **Optical and physical requirements for fluid particles marking trailing vortices from aircraft** L H Back (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.) *Journal of Aircraft*, vol 13, July 1976, p 483-489 37 refs. Contracts No. JPL 953964, No. NAS7-150

A theoretical study of the optical and physical requirements of marking trailing vortices that emanate from aircraft wings was carried out by considering particulate light-scattering properties, ability of particles to follow trailing vortices, and survival time of particles to vortex dissipation. Liquid droplets undergoing evaporation and molecular dispersion were investigated. Droplets should have life times of about 300 sec. Droplet size should be about 1 micron to maximize light scattering with the minimum mass of liquid required. Droplets of this small size would spiral outward very slowly and essentially remain in the vortex cores. Nontoxic hygroscopic liquids, having an affinity for moisture in the air, have been identified. These liquids have relatively low vapor pressures of order 10 to the 5 mm



Hg that would insure droplet persistence long enough to mark trailing vortices (Author)

**A76-37276** , **Passive flutter suppression** C W Ingram (Systems Research Laboratories, Inc., Dayton, Ohio) and W J Szwarc (U S Navy, Naval Air Station Moffett Field, Calif.) *Journal of Aircraft*, vol 13, July 1976 p 542, 543 5 refs

Major results of a subsonic wind tunnel investigation conducted on an NACA 0012 airfoil to determine whether a spanwise slot could increase the flutter velocity of an airfoil are presented. Bending and torsional elements were used which possessed linear structural restoring and damping characteristics. Flutter velocity was studied as a function of static angle of attack. Data clearly shows that the slot does increase flutter velocity, indicating that passive flutter suppression is possible. B J

**A76-37292** **Some aspects of smoke and fume evolution from overheated non-metallic materials** A J Christopher (Royal Aircraft Establishment, Materials Dept., Farnborough, Hants., England) *Journal of Combustion Toxicology*, vol 3, May 1976, p 89-102 7 refs

The development to date of a dynamic system for assessing the smoke and fume emission characteristics of nonmetallic materials is described. A sample of the material under examination is heated from ambient temperature to 500 C in a stream of air. In this way, the behavior of the material under inflight electrical-overheating conditions is simulated more closely than in a smoke-chamber test. Sample temperature, smoke density, and electrode response in a water bubbler are monitored. Results, including 'smoke numbers', obtained for various materials are presented and discussed. (Author)

**A76-37527** **The design and development of a military combat aircraft IV - Lateral stability and control** B R A Burns (British Aircraft Corp., Ltd., Military Aircraft Div., Preston, Lancs., England) *Interavia*, vol 31, July 1976, p 643 646

Lateral stability and control requirements and performance and lateral autostabilization are discussed. Roll control in combat maneuvers, in approach and landing, and in crosswinds is covered, with discussion of enhanced stability needed for rapid rolls and for handling asymmetries (particularly due to unevenly distributed underwing or wing-tip stores, as with projectiles or tanks deliberately retained or not successfully ejected on one side of the craft). Fin size, rudder design, effects of vortex systems, the wing dihedral effect, nuisance Dutch rolls, and yaw off due to poor directional stability are discussed. The discussion applies to lateral control without benefit of fly-by wire. R D V

**A76-37775** **Mechanical and electrical signals assure failsafe operation of aircraft speed brakes** F J Kwantes (Fokker VFW, Schiphol, Netherlands) *Hydraulics and Pneumatics*, vol 29, July 1976, p 67 69

The hydraulic circuitry and valving of a brake control module for opening, closing, and angle positioning clamshell brake doors in the tail cone of the Fokker F 28 twin turbofan passenger aircraft are described. The doors form the fuselage tail cone when closed, and act as a failsafe braking device when opened. The doors can be positioned at any desired angle symmetric with respect to the aircraft centerline. Designing speed brakes as part of the tail rather than the wings allows improved speed stability in landing approaches and improved deceleration behavior on landing, with no effects on wing lift or drag, and hence no adjustments required in trim or engine settings in approach and landing. Deployment of the brake doors at high speeds and at altitude also aids deceleration and descent. R D V

**A76-37781** # **Recent results and summary of higher order boundary-layer research** K Gersten, V Vasanta Ram (Ruhr Universitat, Bochum, West Germany), and J F Gross (Arizona,

University, Tucson, Ariz.) In *Boundary layer effects, Proceedings of the Fourth Data Exchange Agreement Meeting*, Gottingen, West Germany, June 2-3, 1975. Bonn, Bundesministerium der Verteidigung, 1975, p 66-81 27 refs

The higher order boundary-layer theory (HOB layer theory) makes it possible to extend Prandtl's theory toward lower Reynolds numbers. In practice the results obtained with the aid of the HOB layer theory appear to be as good as the solution of the complete Navier-Stokes equations themselves. The flow past a parabola is investigated with the aid of classical boundary layer theory and the HOB-layer theory. The results are compared with the numerical solution of the Navier-Stokes equations. Attention is also given to higher-order effects in stagnation point flows and higher-order boundary-layer effects on a cylindrical surface in supersonic flow. G R

**A76-37782** # **Laminar three dimensional flows past bodies of arbitrary shape** E Elsholz and W Haase (Berlin, Technische Universität, Berlin, West Germany) In *Boundary layer effects, Proceedings of the Fourth Data Exchange Agreement Meeting*, Gottingen, West Germany, June 2-3, 1975. Bonn, Bundesministerium der Verteidigung, 1975, p 82-90 13 refs

The investigation is based on the assumption that the fluid is homogeneous and incompressible. A validity of the Navier-Stokes equations is also assumed. Solutions to the steady-state Navier-Stokes equations are obtained with the aid of difference equations which are solved numerically. The derived algebraic systems are solved by means of the method of successive overrelaxation. The cases studied include the flow past a sphere and past a spheroid. G R

**A76-37783** # **Unsteady boundary layer research at VKI** H J Wirz (Institut von Karman de Dynamique des Fluides, Rhode-Saint-Genese, Belgium) In *Boundary layer effects, Proceedings of the Fourth Data Exchange Agreement Meeting*, Gottingen, West Germany, June 2-3, 1975. Bonn, Bundesministerium der Verteidigung, 1975, p 91 95

Research concerning unsteady laminar boundary layers related to the development of finite difference methods, the problem of 'separation' and applications involving arbitrary pressure gradients is considered. Finite difference methods have been developed for the study of unsteady incompressible and compressible boundary layers, taking into account heat transfer. A conceptual difficulty regarding the definition of the point of separation in unsteady boundary layers is also discussed. G R

**A76-37784** # **Turbulent flow connected with separation and reattachment** V Vasanta Ram and P Wauschkuhn (Ruhr Universität Bochum, West Germany) In *Boundary layer effects, Proceedings of the Fourth Data Exchange Agreement Meeting*, Gottingen, West Germany, June 2-3, 1975. Bonn, Bundesministerium der Verteidigung, 1975, p 96-103

The incompressible two dimensional flow past a rearward-facing step is considered as an example of a flow involving separation. The parameters determining the flow characteristics are examined, taking into account two Reynolds numbers related to the geometrical dimensions of the step. Aspects concerning incremental drag and the reattachment problem are investigated. The problem of the relaxing boundary layer (or wake) downstream of reattachment is discussed, giving attention to experimental studies and theoretical investigations. G R

**A76-37785** # **The influence of low free stream turbulence on the development of the turbulent boundary layer at zero pressure gradient - Preliminary results** H U Meier (Aerodynamische Versuchsanstalt, Gottingen, West Germany) In *Boundary layer effects, Proceedings of the Fourth Data Exchange Agreement Meeting*, Gottingen, West Germany, June 2-3, 1975. Bonn, Bundesministerium der Verteidigung, 1975, p 104 118

Experiments on air flow over a flat sidewall of a low-turbulence wind tunnel are described. Boundary layer measurements were

carried out at a fixed distance from the nozzle exit in the freestream velocity range of 10 m/sec to 40 m/sec. For these test conditions the response of the turbulent boundary layer to the turbulence level in the external free stream was studied. In order to increase the low turbulence level of the tunnel from 0.2% to Tu 1.3%, a grid with square mesh was installed at the nozzle exit. (Author)

**A76-37787 #** A finite difference method for the calculation of three-dimensional boundary layers on swept wings. G. R. Schneider (Aerodynamische Versuchsanstalt Gottingen, West Germany). In: Boundary layer effects, Proceedings of the Fourth Data Exchange Agreement Meeting, Gottingen, West Germany, June 2-3, 1975. Bonn, Bundesministerium der Verteidigung, 1975, p. 144-168. 7 refs.

A numerical method is presented to calculate the three-dimensional incompressible turbulent boundary layer on swept wings for different angles of yaw and different pressure distributions. The governing turbulent boundary layer equations are integrated using an implicit finite difference procedure with variable step sizes in conjunction with the mixing length hypothesis for the distribution of the turbulent shear stress. The two nonlinear turbulent momentum equations are linearized each in one direction. The following linear equations are solved one after the other in an iterative procedure for which the starting values are extrapolated from the last two stations. The number of iterations is controlled by the velocity values normal to the wall. As starting profile for the whole numerical procedure a two-dimensional turbulent boundary layer profile with zero pressure gradient is used. (Author)

**A76-37802 #** Engineering cost characteristics of modern passenger aircraft (Charakterystyki techniczno-ekonomiczne wspolczesnych samolotow komunikacyjnych). K. Rzemek. *Technika Lotnicza i Astronautyczna*, vol. 31, June 1976, p. 19-22. In Polish.

Approaches to cost assessment and cutting operating costs are surveyed. Cost analysis items, fuel costs and their evaluation, methods adopted by various airlines in cost analysis, depreciation write-offs, insurance costs, labor costs, cost per passenger seat-km, and optimization of performance variables in terms of costs are considered. Optimum speed, optimum altitude, best wing conditions and control surface design for cutting fuel costs per load carried and range, ways of improving engine thrust and lift/drag ratio without adding to cost, are also discussed. R. D. V.

**A76-37803 #** Technological problems in the manufacture of compressor blading (Problemy technologiczne przy produkcji lopatek sprzarkowych). A. Goleczynski. *Technika Lotnicza i Astronautyczna*, vol. 31, June 1976, p. 24-26. 5 refs. In Polish.

Work by Polish institutes on improving the fatigue strength, corrosion resistance, and surface qualities of blades for axial flow compressors is reviewed. Tests of compressor blade surface quality after vibration shot peening are dealt with. The vibration shot peening technique does away with scratches resulting from grinding and polishing that act as nuclei for fatigue cracks and corrosion, and leaves a smoother hardened surface with enhanced resistance to fatigue and corrosion. Tests conducted on the WED 200 electrodynamic test stand are described. Improvements of 20 to 40% in fatigue strength are reported. Fatigue cracks and scratches initiated at the thin leading and trailing edges of the blades are eliminated in the vibration aided shot peening treatment. R. D. V.

**A76-37804** Environmental noise impact of Army helicopters. A. B. Broderson and R. G. Edwards (Watkins and Associates, Inc.). *Journal of Environmental Sciences*, vol. 19, May/June 1976, p. 9-18. 28 refs. Army supported research.

An environmental impact study was performed to assess the effects of a program of low level helicopter training flights over public and private lands surrounding a military preserve. Noise analyses conducted for the Kiowa, Huey, Cobra, and Chinook

helicopters included octave band analyses during hovering and sound level time histories during flyovers in groups of one, two, and four helicopters at distances of 50, 500 and 2000 ft. A community attitude questionnaire was circulated, and ambient sound levels were measured. Community attitudes were found to be in good agreement with those predicted by composite noise rating analyses, the values obtained by noise exposure forecast were found to be conservative. Potential adverse community reactions and undesirable effects on wildlife were avoided insofar as possible by selection of optimum flight paths on the basis of the results of the study. C. K. D.

**A76-37814 #** On the unsteady motion of a thin body in an incompressible fluid. D. Homencovschi. *Bulletin Mathematique*, vol. 18 (1974), no. 1-2, 1975, p. 133-141. 5 refs.

The author derives a closed-form solution of the linearized hydrodynamic equations written in distributions for a thin profile in unsteady motion in an incompressible inviscid fluid, where unsteadiness is due to both the time dependence of the profile velocity and to oscillations of the surface. Under certain conditions, this solution permits calculation of the profile lift. This is done for several cases: (1) a profile moving along a fixed curve at small incidence, (2) a profile with a sudden change in its direction, and (3) a profile moving along a circle. P. T. H.

**A76-37821 #** Perturbation potential for a thin wing of small span (Das Störpotential für den dünnen Flügel kleiner Spannweite). S. Turbatu. *Bulletin Mathematique*, vol. 18 (1974), no. 3-4, 1976, p. 415-423. 8 refs. In German.

The paper examines the nonlinear parabolic differential equation for the velocity potential of the unsteady aperiodic transonic flow past a thin wing of small span on the basis of small perturbation theory. The wing is subject to momentary changes in shape or position. The method neglects the effects of friction, heat transfer and intense shocks and solves a series of parabolic boundary value problems for perturbation potential in steady and unsteady flows. B. J.

**A76-37845 #** The unsteady forces on flat plate-airfoils in cascade moving through sinusoidal gusts. S. Murata and Y. Tsujimoto (Osaka University, Suita, Osaka, Japan). *Zeitschrift für angewandte Mathematik und Mechanik*, vol. 56, May 1976, p. 205-216. 12 refs.

The paper presents an analysis for the determination of lift fluctuation on flat plate airfoils in cascade due to transverse and chordwise gusts. The acceleration potential method is used in combination with conformal mapping. This method gives a simple analysis even for cascades without the complicated integral equations inevitable in the determination of vortex distribution in velocity-field analysis. The computational results show that the pitch and the stagger angles of the cascade have considerable effect upon the magnitude of the fluctuating lift, but less effect upon phase angle. (Author)

**A76-37876** Supersonic flow past axisymmetric bodies in the presence of a perforated wall (Obtekanie osesimmetrichnykh tel sverkhzvukovym potokom v prisutstvii perforirovannoi stenki). M. P. Riabokon'. *TsAGI, Uchenye Zapiski*, vol. 5, no. 1, 1974, p. 1-6. In Russian.

The paper analyzes the interaction of waves generated by an axisymmetric body in a supersonic flow with a perforated wall. The following wind tunnel test is modeled: A cone-cylinder test body is placed in the perforated working section of a wind tunnel of square cross section in a supersonic gas flow at Mach number 1.5, cone aperture half angle of 10 deg, and relative loading of the working section by the model of 2%. Analysis of the velocity hodograph curves shows that under conditions of an unbounded flow the required wall permeability distribution for ensuring total extinction of generated waves is physically unrealizable at certain sections. A method is described for calculating the intensity of a reflected wave when the wall permeability distribution is less than optimal. P. T. H.

**A76-37877 #** Weak viscous interaction at a plate with broken leading edge (O slabom viazkom vzaimodeistvii na plastine s izlomom perednei kromki) V V Mikhailov *TsAGI, Uchenye Zapiski*, vol 5, no 1, 1974, p 7 16 6 refs In Russian

Analysis of the laminar flow of a perfect gas in a hypersonic boundary layer around a flat plate having a break in its sharp leading edge. It is assumed that the angle of attack and degree of viscous interaction are small, and that at each longitudinal section the outer inviscid flow can be considered two dimensional. An asymptotic solution is derived for this flow regime, which enables estimation of the effect of the leading edge break on pressure, friction, and heat transfer. It is found that the perturbations propagate along the whole boundary layer, although their influence region is relatively small.

P T H

**A76-37883** Method for determining the parameters of a uniform strength, variable-thickness cantilever plate under prescribed permissible stresses, loads, and structural constraints (Metod opredeleniia parametrov ravnoprochnoi konsol'noi plastiny peremennoi tolschchiny pri zadannykh dopuskaemykh napriazheniakh, nagruzkakh i konstruktivnykh ogranicheniakh) T G Zuraev *TsAGI, Uchenye Zapiski*, vol 5, no 1, 1974, p 60 65 In Russian

**A76-37885 #** Aerodynamic characteristics of blunt bodies with elliptical cross sections (Aerodinamicheskie kharakteristiki zatuplennykh tel s ellipticheskimi poperechnymi secheniiami) G G Nersesov *TsAGI, Uchenye Zapiski*, vol 5, no 1, 1974, p 77 81 7 refs In Russian

A modification of the finite difference technique of Babenko et al. was used to calculate the aerodynamic coefficients of elongated blunt bodies with elliptical cross sections. Calculations were made of the three-dimensional supersonic flow of a perfect gas past bodies with blunt nose section, whose cross section consists of two half ellipses of equal semimajor axis but different semiminor axis. At one end the bodies are spherically blunted, while for the rest of the body the semimajor axis varies linearly and the semiminor axis varies at first parabolically and then linearly. The modification of the method consists in recalculating gasdynamic parameters in those flow regions where the necessary stability condition for the reverse sweep is violated. Calculations were performed for a perfect gas at freestream Mach numbers of 2 and 6 in the incidence range from 10 to 20 deg. It is seen that bodies with more convex windward side and less convex leeward side have higher lift.

P T H

**A76-37886 #** Corrections for the effect of flow boundaries /tunnel induction/ to the aerodynamic characteristics of models tested near a screen (O popravkakh na vlianie granits potoka /induktsiiu trub/ k aerodinamicheskim kharakteristikam modelei, ispytyvaemykh vblizi ekrana) S D Ermolenko, Iu A Prudnikov, and V U Sobolenko *TsAGI, Uchenye Zapiski*, vol 5, no 1, 1974, p 83 85 In Russian

**A76-37887 #** Comparison of calculated and experimental values of the efficiency and hinge moments of elevons on thin isolated wings of small aspect ratio (Sravnenie raschetnykh i eksperimental'nykh znachenii effektivnosti i sharnirnykh momentov elevonov na tonkikh izolirovannykh kryl'akh malogo udlineniia) G G Zykova, A I Kalinin, V G Mikeladze, and A Zh Rekstin *TsAGI, Uchenye Zapiski*, vol 5, no 1, 1974, p 86-90 In Russian

A comparison is made between the results of systematic experiments and the results of computer calculations by the method of discrete vortices for the efficiency and hinge moments of elevons on thin wings of small aspect ratio with a break in the leading edge of sweep angle 65 and 55 deg and on a wing without break in the leading edge of sweep angle 55 deg. The influence of the number of vortices modeling the wing on calculated results is studied. Attention is also given to the mutual effect of deviation of the elevons on the right and left halves of the wing.

P T H

**A76-37888 #** Discharge into a submerged space of a supersonic fan jet of an ideal gas with uniformly assigned parameters in

the initial section (Istечение в затопленное пространство сверхзвуковой веерной струи идеального газа с равномерным заданием параметров в начальном сечении) V I Blagosklonov and M Ia Ivanov *TsAGI, Uchenye Zapiski*, vol 5, no 1, 1974, p 91-96 16 refs In Russian

A numerical solution is given for the spreading of a supersonic fan (radial) jet of inviscid and non-heat-conducting gas along an obstacle with uniform distribution of parameters in the initial section for a wide range of variation of Mach number in the initial jet section, pressure ratio, distance from the spreading axis to the initial jet section, and adiabatic index. In this range of governing parameters, regular reflection of a trailing shock wave from the obstacle surface takes place. The geometrical dimensions of the fan jet, as in the case of an ordinary axisymmetric jet, depend linearly on the Mach number and the square root of the pressure ratio.

P T H

**A76-37890 #** Effect of discrete suction on the characteristics of a three-dimensional laminar boundary layer on a gliding wing (Vlianie diskretnosti otsasyvaniia na kharakteristiki trekhmernogo laminarnogo pogrannichnogo sloia na skol'ziaschem kryle) V A Barinov *TsAGI, Uchenye Zapiski*, vol 5, no 1, 1974, p 104 107 5 refs In Russian

A scheme for calculating the characteristics of the flow past a wing with suction slots by considering a certain discrete distribution of the suction rate rather than a continuous one. Values of local Reynolds number are calculated by the method of integral relations for the profiles of the velocity components along a streamline of the external flow and in a direction perpendicular to it, and are compared with the smallest critical Reynolds numbers for the profiles investigated. A similar comparison is made for continuous distributed suction, revealing the destabilizing effect of nonporous surface segments.

P T H

**A76-37891 #** Experimental study of flow in the wake behind flat bodies with blunt stern section using optical methods (Eksperimental'noe issledovanie techeniia v slede za ploskimi telami s tupym kormovym srezom s primeneniem opticheskikh metodov) Z A Anan'eva, V R Bertyn', G V Zemtsova, A V Podmazov, and B V Ponomarev *TsAGI, Uchenye Zapiski*, vol 5, no 1, 1974, p 108 112 12 refs In Russian

Using optoelectronic methods for recording density gradients, the flow past wedge models at subsonic flow speeds is studied. Karman vortex streets were observed in the wake behind the models in the whole Mach number range studied (0.2 to 0.9). Flows with double or triple frequency as compared to the Karman frequency were also observed. The Karman structure predominated with respect to time. The appearance of cylindrical acoustic waves propagating against the flow, a phenomenon associated with vortex separation, was recorded.

P T H

**A76-37897 #** Application of the plane-cross-section method in nonlinear wing theory (O realizatsii metoda ploskikh sechenii v nelineinoy teorii kryla) V F Molchanov *TsAGI, Uchenye Zapiski*, vol 5, no 2, 1974, p 19 10 refs In Russian

A computational scheme for applying the plane-cross section method in nonlinear wing theory is developed on the basis of a theory for solving incorrectly posed problems. The scheme is suitable for both self-similar and non self similar flows. Forms of tangential discontinuities adjoining leading edges are determined, and nonlinear characteristics of the lifting power of delta wings are calculated.

F G M

**A76-37898 #** Calculation of stalled flow about a slender delta wing of small aspect ratio (Raschet otrynnogo techeniia okolo tonkogo treugol'nogo kryla malogo udlineniia) G G Sudakov *TsAGI, Uchenye Zapiski*, vol 5, no 2, 1974, p 10 18 9 refs In Russian

The paper considers a steady flow of ideal gas or fluid about a delta wing in the presence of stalled flow behind sharp leading edges in the slender body approximation. In the problem, a continuous

vortex sheet is modulated by discrete vortices, and measures are taken to assure the dynamic stability of the chain of discrete vortices. The nucleus of the vortex sheet is described by the model of Mangler and Smith (1959), generalized for the case of nonconical flows. The configuration of the vortex layers, the lift coefficient, and the pressure distribution on the surface of the delta wing at a 10-deg angle of attack as well as in the presence of slip are calculated by computer and compared with experimental results. F G M

**A76-37899 #** Effect of the shape of a lifting body on its lifting power at supersonic and hypersonic flying speeds (Vlianie formy nesushchego tela na ego pod'emnuu silu pri sverkhzvukovykh i giperzvukovykh skorostiakh poleta) V V Keldysh *TsAGI, Uchenye Zapiski*, vol 5, no 2, 1974, p 19-26. In Russian

Theoretical and experimental data are presented which show that the lift coefficient (as a function of angle of attack) of lifting bodies depends substantially on the shape of the bodies and their relative thickness in the case of high supersonic speeds (Mach numbers between 6 and 10). It is found that the lift coefficient of a wedge-shaped or conic lifting body may be considerably higher than that of a slender wing at such speeds. However, at moderate supersonic speeds (Mach numbers of 2 to 3) and similar aspect ratios, the lift coefficients at angles of attack not exceeding 10 deg will be practically the same for both configurations. F G M

**A76-37900 #** Is supersonic flight possible without sonic booms (Vozmozhno li sverkhzvukovoi samolet bez zvukovogo udara) G I Taganov *TsAGI, Uchenye Zapiski*, vol 5, no 2, 1974, p 27-37. 8 refs. In Russian

Limiting cases of waveless thrust and lift formation in a supersonic flow are examined. It is shown that with certain ratios between the transverse and longitudinal dimensions of a lifting system, the contribution of lifting power to sonic-boom energy is decreased, and the equivalent-body length increases. Additional energy consumption associated with shock-boom alleviation during supersonic flight is estimated. F G M

**A76-37901 #** Conditions for the onset of focusing in the presence of a sonic boom (Usloviia vozniknoveniia fokusirovki pri zvukovom udare) Iu L Zhilin *TsAGI, Uchenye Zapiski*, vol 5, no 2, 1974, p 38-43. In Russian

It is shown analytically that focusing in the presence of a sonic boom may be initiated by two different causes. In the first case, the onset of focusing is associated with aircraft maneuvers and an atmospheric parameter gradient at the flight altitude. Focusing in the second case originates during ray reflection and is associated with an atmospheric inhomogeneity along the ray trajectory (atmospheric focusing). Calculations are performed which demonstrate that three conditions must be fulfilled for the onset of atmospheric focusing and that this phenomenon consequently has a low probability of occurrence. Experimental data confirming these conclusions are presented. F G M

**A76-37905 #** Theory on the interaction of a hypersonic flow with a boundary layer for two- and three-dimensional stalled flows. I - Three-dimensional flows (K teorii vzaimodeistviia giperzvukovogo potoka s pogranichnym sloem dlia otryvnykh dvumernykh i prostranstvennykh techenii. I - Prostranstvennye techeniia) V Ia Neiland *TsAGI, Uchenye Zapiski*, vol 5, no 2, 1974, p 70-79. 13 refs. In Russian

Properties of disturbance propagation and the formulation of the boundary value problem are examined for a boundary layer on a delta wing in the case where the interaction with the outer hypersonic flow is not weak and the temperature of the body is low in comparison with the stagnation temperature of the oncoming flow. It is shown that a three-dimensional boundary layer in interaction regimes is analogous to a two-dimensional nonviscous flow. Except for flow surfaces, the boundary layer equations for cold bodies and wakes are found to possess two families of characteristics (as does a supersonic flow) which limit the regions of disturbance

transfer. For the subcritical regime, which is analogous to a subsonic flow, the solution near the leading edge contains an arbitrary function which may be determined from conditions at the singular line, which is analogous to the sonic line of a two dimensional flow. Special attention is given to supercritical flows on a delta wing with subcritical and supercritical leading edges. F G M

**A76-37908 #** Taking account of fatigue in a stub-wing structure with computation by the method of forces (Ob uchete oslablenii v konstruktsii kryla malogo udlineniia pri raschete metodom sil) B N Antiukhov and G S Elenevskii *TsAGI, Uchenye Zapiski*, vol 5, no 2, 1974, p 96-104. In Russian

Exact and approximate techniques are described for calculating local fatigue in a stub wing structure when a finite element method is implemented as a method of forces. The exact technique is based on the conditional minimum theorem, while the approximate one is based on the use of a computer program for calculating a regular structure by gradually reducing the stiffness of eliminated structural elements. Examples are presented in which intrinsic forces in the wing elements are computed by both techniques, and it is found that the two techniques yield very similar results. F G M

**A76-37913 #** Use of a helium blast for the visual study of air flow patterns about bodies (Ispol'zovanie vduva geliia dlia vizual'nogo izucheniia kartiny obtekanii tel vozdukhom) V M Bozhkov and V M Zakharchenko *TsAGI, Uchenye Zapiski*, vol 5, no 2, 1974, p 136-138. In Russian

**A76-37923 #** Theory of the curvilinear unsteady motion of a thin lifting body in a gas (K teorii krivoliniinogo nestatsionarnogo dvizheniia v gase nesushchego tonkogo tela) V E Baskin *TsAGI, Uchenye Zapiski*, vol 5, no 3, 1974, p 10-17. In Russian

The paper examines the curvilinear unsteady motion of a permeable lifting surface with mass sources in an unbounded motionless gas. The velocity and pressure fields of the gas flow induced by the motion of the lifting surface are analyzed. B J

**A76-37929 #** Experimental investigation of the stable self-oscillations of an aileron in transonic flow (Eksperimental'nye issledovaniia ustanovivshikhsia avtokolebaniia elerona v okolozvukovom potoke) Iu I Ageev, V V Nazarenko, and T P Nevezhina *TsAGI, Uchenye Zapiski*, vol 5, no 3, 1974, p 71-80. 6 refs. In Russian

Wind tunnel tests at Mach numbers of 0.94 and 0.95 were conducted on an aileron attached to a symmetrical wing in order to study the nature of aerodynamic damping forces associated with the stable self-oscillations of the aileron. Pressure measurements were performed on the upper surface of the aileron to determine its unsteady aerodynamic characteristics. The existence of regions of positive and negative aerodynamic damping was observed. It was noted that changes in intensity of shock waves and in shock-induced boundary layer separation due to the displacement of wing and aileron lead to the formation of additional unsteady aerodynamic forces defined by the rate of displacement of shock waves and separation zone. B J

**A76-37930 #** Effect of aerodynamic cross linking on the free longitudinal-lateral motion of a flight vehicle (Vlianie aerodinamicheskikh perekrestnykh svyazei na svobodnoe prodol'no-bokovoe dvizhenie letatel'nogo apparata) V V Lukoshkin *TsAGI, Uchenye Zapiski*, vol 5, no 3, 1974, p 81-89. In Russian

The effect of the cross linking of aerodynamic forces and moments on the stability of the perturbed longitudinal-lateral motion of a symmetrical flight vehicle is studied. Approximate expressions are obtained for the roots of the characteristic equation of the longitudinal-lateral motion under the assumption that self-damping of the longitudinal and lateral motion taken separately is small. B J

**A76-37932 #** Systematic calculations of the flow past moving cones on which a shock wave is incident (Sistematische raschety obtekanii dvizhushchikhsia konusov pri padenii na nikh udarnoi volny) R Ia Tugazakov *TsAGI, Uchenye Zapiski*, vol 5, no 3, 1974, p 98-103 7 refs In Russian

A modified Lax Wendroff finite difference scheme is used to solve the problem of shock wave diffraction on a cone moving with constant velocity. Tables describing the distribution of gasdynamic quantities on the surface of the cone as a function of cone velocity (in the Mach number range 1.3-4), the semi-aperture angle of the cone, and the intensity of the incident shock wave are presented.

B J

**A76-37936 #** Unsteady aerodynamic loads on the blade surface of a model of a heavily loaded lifting propeller (Nestatsionnarye aerodinamicheskie nagruzki na poverkhnosti lopasti modeli tiazhele nagruzhennogo nesushchego vinta) V A Golovkin and V M Kaliavkin *TsAGI, Uchenye Zapiski*, vol 5, no 3, 1974, p 119-122 In Russian

Wind tunnel tests were performed to measure the distribution of dynamic pressures on the upper and lower blade surfaces of a heavily loaded lifting propeller model in the horizontal flight regime. It is shown that the lift properties of the propeller are maintained even in the case of a large flow separation regime. This is explained by the fact that the aerodynamic characteristics of the propeller blade profile at the separation region are significantly different from those of a profile in a steady two-dimensional flow.

B J

**A76-37938 #** Resistance of vortex generators at near sonic speeds (Soprotivlenie generatorov vikhrei pri okolozvukovykh skorostyakh) V N Ozerov *TsAGI, Uchenye Zapiski*, vol 5, no 3, 1974, p 128-133 7 refs In Russian

The internal resistance of an isolated vortex generator and of two generators parallel to each other with distance between them varied was measured by means of floating tensometric scales in a wind tunnel in the Mach number range of 0.5-1.0. Measurement results were compared with those of an evaluative model representing the vortex generator as a wing of low aspect ratio, with the boundary layer replaced by a uniform flow with a velocity averaged with respect to the height of the generator examined.

B J

**A76-37940 #** Method for selecting the transfer numbers of a system for the control of the lateral motions of an aircraft (Metod vybora peredatochnykh chisel sistemy upravleniya bokovym dvizheniem samoleta) A I Dynnikov and Iu G Zhivov *TsAGI, Uchenye Zapiski*, vol 5, no 3, 1974, p 142-146 In Russian

The basic requirements placed on the characteristics of the lateral motion of an aircraft are related to the position of the zeros and poles of the corresponding transfer function. A numerical method is presented for determining the transfer numbers of the system for controlling the lateral motions, based on the quadratic form of the differences between values of zero and pole coordinates of the transfer function. The method is applied to the analysis of the control of an aircraft undergoing roll and yaw.

B J

**A76-37941 #** Calculation of radiative heat transfer in aircraft structures (K raschetu luchistogo teploobmena v aviatsionnykh konstruktakh) V M Iudin *TsAGI, Uchenye Zapiski*, vol 5, no 3, 1974, p 147-151 6 refs In Russian

Radiative heat transfer plays the crucial role in determining the temperature distribution of aircraft structures made of low thermal conductivity materials such as titanium and steels and of hypersonic flight vehicles. The zonal method (based on assumptions of constant temperature and degree of blackness at the zone boundaries) for calculating radiative heat transfer is extended to the case of nonisothermal surfaces of aircraft structures.

B J

**A76-38026 #** The issue of source terms for jet noise H S Ribner *American Institute of Aeronautics and Astronautics, Aero Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76 487* 8 p 20 refs

Increasing attention is being focused on Lilley's convected wave equation for the analysis of flow noise. It has the capability, not found in Lighthill's equation, of being able to deal with refraction. The other chief difference stems from the shift of a 'source' term (shear noise) from the right hand side of Lighthill's equation to the left hand side to become a 'propagation amplification' term. It is argued herein, supported by comparative calculations according to theories of Mani and of Ribner, that the alternative roles of the shear term have roughly equivalent effects on jet noise prediction.

(Author)

**A76-38028 #** On the amplification of broadband jet noise by a pure tone excitation D Bechert and E Pfizenmaier (Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt, Institut für Turbulenzforschung, Berlin, West Germany) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76 489* 8 p 7 refs

Common practice has been to consider the total noise output of an aircraft engine to be composed of several independent contributions. The present investigation, however, shows that broadband jet noise can be amplified by a pure tone excitation as much as 6 to 7 dB. This effect is found to occur at sound pressure levels which are present in real aircraft engines. The experiments were carried out with a cold jet at high subsonic Mach numbers excited by sound waves coming from inside the nozzle. Based on a simplified theoretical model an attenuator has been constructed which is able to reduce the jet noise amplification considerably.

(Author)

**A76-38037 \* #** Comparison of predictions and under-the-wing EBF noise data M R Fink and W A Olsen (NASA, Lewis Research Center, V/STOL and Noise Div., Cleveland, Ohio) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76 501* 14 p 16 refs

Detailed three dimensional free field noise data were obtained by NASA for an under the wing externally blown model three-flap wing, and for a similar slotless wing. Spatial (polar and azimuthal) and spectral characteristics of these data are presented. These data are compared with predictions from some published EBF noise calculation methods. Methods include the totally empirical ANOPP and GELAC procedures, and a semiempirical noise component method. The latter method adds the separately computed dipole noise due to fluctuating lift and drag, trailing edge noise, and quadrupole noise due to the deflected jet. Each of these components is calculated for the local geometry and flow conditions.

(Author)

**A76-38038 #** Jet/surface interaction noise - Analysis of farfield low frequency augmentations of jet noise due to the presence of a solid shield R W Head and M J Fisher (Southampton University, Southampton, England) *American Institute of Aeronautics and Astronautics, Aero Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76 502* 8 p. Research supported by the Ministry of Defence (Procurement Executive).

**A76-38039 \* #** Mach wave emission from supersonic jets S P Parthasarathy and P F Massier (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76 505* 13 p. Contract No NAS7 100

An experimental investigation has been conducted on supersonic jets at a Mach number of 1.43 over a temperature range from about 420 K to 1370 K (300 F to 2000 F) in which it was found that the noise in the far field was dominated by eddy Mach waves. It is shown

that the strength of the Mach waves is determined by the product of the mean shear and the density fluctuations of the jet. Thus, the source of sound arises from the mixing of hot and cold streams as well as from those compressions and expansions that are intuitively associated with sound generation. For the temperature range investigated, the Mach waves were emitted at angles between 37 deg and 59 deg with respect to the jet axis. These values represent those in the region of the jet where the Mach angle was constant. (Author)

**A76-38040 #** Noise of swirling exhaust jets. H. Y. Lu, J. W. Ramsay, and D. L. Miller (Boeing Commercial Airplane Co., Seattle, Wash.) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-510* 7 p

Noise and flow characteristics of model swirling jets were measured. A swirling jet from a plug-nozzle generated a strong vortex flow and a broadband noise higher than that of a nonswirling jet. Exit guide vanes were found to be able to decrease the swirl and the noise simultaneously. A swirling jet with a nonswirling jet core flow was tested. The nonswirling core flow prevented the formation of strong vortex and kept the swirling jet noise at a relatively lower level. Noise attenuation for this flow only occurred at small angles from jet axis. The noise increase of the swirling jet over the nonswirling jet was found to depend on swirl angle, pressure ratio and total temperature of the jet. (Author)

**A76-38042 #** Exact Wiener-Hopf solution of multi-section duct liners. W. Koch (Aerodynamische Versuchsanstalt, Gottingen, West Germany) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-513* 11 p 13 refs

An extension of the Wiener-Hopf technique is outlined and applied to the solution of sound attenuation by multisection duct liners in series as well as in parallel for the simple no-flow case and a rectangular duct. Results are presented for the acoustic power attenuation of the fundamental mode in order to show the influence of major design parameters for point reacting liners. The broad-band attenuation capacity of some liner configurations is clearly demonstrated. For multimode excitation the incoming unattenuated modes have to be specified. (Author)

**A76-38043 \* #** Effects of multi-element acoustic treatment on compressor inlet noise. R. E. Kraft, J. E. Paas (General Electric Co., Aircraft Engine Group, Evendale, Ohio), and L. R. Clark (NASA, Langley Research Center, Hampton, Va.) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-515* 10 p Contract No. NAS113416

An analytic and experimental study was conducted with the objective of developing both a basic understanding of axially segmented inlet acoustic treatment liners, and design procedures for enhancing the suppression of compressor inlet radiated noise. Anechoic chamber measurements demonstrated that the multi-element treatment produced significantly more low frequency suppression than uniform treatment. Further, in-duct spinning mode patterns generated by the rotating vehicle were successfully measured and used as input to an analytical prediction procedure, providing significant improvement in inlet suppression predictions. The study indicated that phased inlet liners can be designed to provide increased noise suppression compared to uniform treatment. (Author)

**A76-38047 \* #** An experimental study of the aeroacoustics of a subsonic jet impinging normal to a large rigid surface. J. S. Preisser and P. J. W. Block (NASA, Langley Research Center, Hampton, Va.) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-520* 9 p 12 refs

This paper presents results from an experimental study of unsteady surface pressures and far field noise produced by a subsonic jet impinging normal to a large, rigid, flat surface. The tests were

performed in an anechoic room for jet Mach numbers from 0.54 to 0.85, and for jet-to-surface heights of from 5 to 10 jet diameters. Results showed that the root-mean-square surface pressure levels were proportional to jet dynamic pressure and were independent of jet height for radial distances from the stagnation point greater than 3 jet diameters. Far-field measurements indicated a significant increase in noise over that of a free jet for all cases of impingement. Cross spectral calculations between the surface and the far field suggested that at a Mach number of 0.70 and a height of 5 jet diameters the additional noise originated mainly in the outer edge of the impingement region between 1 and 3 jet diameters from the stagnation point. (Author)

**A76-38048 \* #** OTW noise correlation for variations in nozzle/wing geometry with 5:1 slot nozzles. U. von Glahn and D. Groesbeck (NASA, Lewis Research Center, Cleveland, Ohio) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-521* 12 p 18 refs

Acoustic data obtained from a model scale study with 5:1 slot nozzles are analyzed and correlated in terms of apparent noise sources. Variations in nozzle geometry include roof angle and sidewall cutback. In addition, geometry variations in wing size and flap deflection were included. Three dominant noise sources were evident in the data and correlated: fluctuating lift noise, trailing edge noise and a redirected jet mixing noise that included the effect of reflection of jet noise by the surface. Pertinent variables in the correlations included the shear layer thickness and peak jet flow velocity at the trailing edge. (Author)

**A76-38049 \* #** The aerodynamic and acoustic characteristics of an over-the-wing target-type thrust reverser model. M. D. Falarski (NASA, Ames Research Center, U.S. Army, Air Mobility Research and Development Laboratory, Moffett Field, Calif.) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-523* 7 p 7 refs

A static test of a large scale, over the wing (OTW) powered lift model was performed. The OTW propulsion system had been modified to incorporate a simple target type thrust reverser as well as the normal rectangular OTW exhaust nozzle. Tests were performed in both the reverse thrust and approach configurations. The thrust reverser noise created by jet turbulence mixing and the OTW approach noise were both low frequency and broadband. When scaled to a 45,400 kg (100,000 lb) aircraft, the thrust reverser and approach configurations produced peak 152 m (500 ft) sideline perceived noise levels of 110 and 105 PNdB respectively. The aerodynamic performance of the model showed that 50% or greater reverser effectiveness can be achieved without experiencing ingestion of exhaust gas or ground debris into the engine inlets. (Author)

**A76-38050 \* -** A vortex model of cavity flow. J. C. Hardin and J. P. Mason (NASA, Langley Research Center, Hampton, Va.) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-524* 8 p 14 refs

The paper presents a model of two dimensional cavity flow in which the shear layer over the cavity is represented by discrete rectilinear vortices which are free to move as the flow progresses. Although the model is initially started impulsively, the computation is continued until a statistically steady flow is attained. The broadband noise generation of the cavity is calculated by first running the model until the steady state is reached and then computing a stationary record of far field density fluctuation through an equation that is suitable for calculating the quadrupole noise generation by the model. The discrete time series obtained can be analyzed by ordinary digital spectral techniques to determine the spectra and overall levels of the noise in airframe noise testing of real aircraft. S D

**A76-38051 #** Approximate prediction of airframe noise. M R Fink *American Institute of Aeronautics and Astronautics, Aero Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-526* 7 p 17 refs

A simple approximate method is presented for calculating airframe flyover noise. Two different equations are given, corresponding to the functional dependences expected for aerodynamically clean aircraft and for aircraft with extended or fixed landing gear. Minimum airframe noise is achieved by high-performance sailplanes and by some jet-propelled aircraft. Such noise is shown to have the level and directivity predicted for trailing edge noise caused by the wing turbulent boundary layer. This minimum is approximately proportional to wing area but independent of aspect ratio. Noise from typical conventional aircraft with retracted landing gear but with wing-mounted nacelles or large trailing edge flap tracks follows the same trends but is 8 dB louder. (Author)

**A76-38052 \* #** Semi-empirical airframe noise prediction model. A S Hersh (Hersh Acoustical Engineering, Chatsworth, Calif), T W Putnam, P L Lasagna, and F W Burcham, Jr (NASA, Flight Research Center, Edwards, Calif). *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-527* 8 p 12 refs

A semi-empirical maximum overall sound pressure level (OASPL) airframe noise model was derived. The noise radiated from aircraft wings and flaps was modeled by using the trailing-edge diffracted quadrupole sound theory derived by Ffowcs Williams and Hall. The noise radiated from the landing gear was modeled by using the acoustic dipole sound theory derived by Curle. The model was successfully correlated with maximum OASPL flyover noise measurements obtained at the NASA Dryden Flight Research Center for three jet aircraft: the Lockheed JetStar, the Convair 990, and the Boeing 747 aircraft. (Author)

**A76-38053 #** The outlook for simulation of forward flight effects on aircraft noise. D G Crighton (Leeds University, Leeds, England), J E Ffowcs Williams (Cambridge University, Cambridge, England), and I C Cheeseman (Southampton University, Southampton, England). *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-530* 14 p 23 refs

The technical questions related to an assessment of flight simulation techniques are considered. Formulas which describe the effect of forward flight on various types of acoustic sources are considered and a summary is presented of information concerning the possible effects of forward flight on pure jet mixing noise. Flight simulation facilities are discussed, giving attention to tracked vehicles, a spinning rig, an open jet wind tunnel, and a closed wind tunnel. A description is given of the approaches available for simulating flight effects. G R

**A76-38055 #** Use of the Bertin Aérotrain for the investigation of flight effects on aircraft engine exhaust noise. R G Hoch (SNECMA, Paris, France) and M Berthelot (Société Bertin et Cie, Plaisir, Yvelines, France). *American Institute of Aeronautics and Astronautics, Aero Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-534* 11 p 6 refs

A prototype of the Aerotrain has been modified by SNECMA and Société Bertin to investigate flight effects on jet noise and jet suppressor performance. To this end, special attention was given to the reduction of parasitic noise from the vehicle and internal noise from the GE-J85 turbojet engine which powers the Aerotrain. The vehicle, its performance, the operational techniques, the measurement and analysis procedures used are fully described, together with the results of the calibration tests of this unique and very flexible facility which presents many advantages compared to aircraft in flight. Typical results, consistent with the trends shown by clean aircraft noise data, are presented. (Author)

**A76-38059 \* #** Aerodynamic and acoustic performance of a contracting cowl high throat Mach number inlet installed on NASA Quiet Engine 'C'. H E Bloomer and J W Schaefer (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aero Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-540* 12 p 10 refs

The purpose of this experimental program was to evaluate the approach and takeoff performance of a contracting cowl variable geometry design inlet installed on a high bypass ratio turbofan engine. The design was finalized after consideration of aerodynamic, acoustic, and mechanical factors which would lead to a viable flight worthy inlet concept. The aerodynamic results are presented in terms of inlet recovery and distortion parameter as functions of throat Mach number, and acoustic results in terms of Perceived Noise Level. The contracting cowl high throat Mach number inlet is shown to be an attractive means to reduce forward radiated noise from a high bypass ratio turbofan engine. (Author)

**A76-38060 \* #** Noise reduction as affected by the extent and distribution of acoustic treatment in a turbofan engine inlet. G L Minner and L Homyak (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aero Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-541* 13 p 9 refs

An inlet noise suppressor for a TF 34 engine designed to have three acoustically treated rings was tested with several different ring arrangements. The configurations included all three rings, two outer rings, single outer ring, single intermediate ring, and finally no rings. It was expected that as rings were removed, the acoustic performance would be degraded considerably. While a degradation occurred, it was not as large as predictions indicated. In fact, the prediction showed good agreement with the data only for the full ring inlet configuration. The under-predictions which occurred with ring removal were believed a result of ignoring the presence of spinning modes which are known to damp more rapidly in cylindrical ducts than would be predicted by least attenuated mode or plane wave analysis. (Author)

**A76-38062 \* #** Numerical evaluation of the jet noise source distribution from far-field cross correlations. L Maestrello and C H Liu (NASA, Langley Research Center, Hampton, Va). *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-543* 8 p 9 refs

This paper contains the development of techniques to determine the relationship between the unknown source correlation function to the correlation of scattered amplitudes in a jet. This study has application to the determination of forward motion effects. The technique has been developed and tested on a model jet of high subsonic flow. Numerical solution was obtained by solving the Fredholm integral equation of the first kind. Interpretation of the apparent source distribution and its application to flight testing are provided. (Author)

**A76-38063 #** Radiation, refraction and scattering of acoustic waves in a free shear flow. S M Candel (ONERA, Châtillon sous Bagneux, Hauts-de-Seine, Compiègne, Université de Technologie, Compiègne, France), A Guedel, and A Julienne (ONERA, Châtillon sous Bagneux, Hauts-de-Seine, France). *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-544* 18 p 24 refs

The present analysis concerns the sound field produced by a driver unit placed in the free jet of the Von Karman Institute open tunnel. Refraction and radiation effects are characterized by measurements of phase and amplitude. Good agreement is obtained between experimental data and numerical predictions based on a combination of the geometrical approximation and a simple model for radiation in the presence of a uniform flow. A space-time-

frequency analysis indicates that the scattered sound field is quasi-periodic and may be considered as a projection of the turbulent flow. Eduction techniques applied simultaneously to the turbulent and acoustic fields confirm this view and allow further extraction of the mean wave components associated to the large scale structure of the shear flow (Author)

**A76-38064 #** Shielding and scattering by a jet flow S M Candel (ONERA, Châtillon sous Bagneux, Hauts-de-Seine, Compiègne, Université de Technologie, Compiègne, France), M Julland (SNECMA, Paris, France), and A Julienne (ONERA, Châtillon-sous-Bagneux, Hauts-de-Seine, France) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-545* 16 p 21 refs

This paper describes, in the first part, experimental results on the masking characteristics of a two-dimensional jet flow. It is found that the shielding effectiveness strongly depends on the basic directivity and orientation of the noise source (driver unit or jet noise). The second part of the paper deals with the characterization of the scattered acoustic field by space time and frequency techniques. Through spectral, cross spectral and correlation analysis, it can be shown that the scattered field retains the convective wavelike nature of the turbulent jet flow. Applications of these results may be found in internal noise radiation and jet noise shielding (Author)

**A76-38066 \*** Wing shielding of high velocity jet and shock-associated noise with cold and hot flow jets U von Glahn, D Groesbeck, and J Wagner (NASA, Lewis Research Center, Cleveland, Ohio) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-547* 13 p 6 refs

Jet exhaust noise shielding data are presented for cold and hot flows (ambient to 1100 K) and pressure ratios from 1.7 to 2.75. A nominal 9.5 cm diameter conical nozzle was used with simple shielding surfaces that were varied in length from 28.8 to 114.3 cm. The nozzle was located 8.8 cm above the surfaces. The acoustic data with the various shielding lengths are compared to each other and to that for the nozzle alone. In general, short shielding surfaces that provided shielding for subsonic jets did not provide as much shielding for jets with shock noise, however, long shielding surfaces did shield shock noise effectively (Author)

**A76-38067 \*** An approach to the prediction of airplane interior noise J F Wilby *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-548* 10 p 20 refs Contract No NAS1-11839

At present there is no well proven method of calculating airplane interior noise associated with jet and boundary layer sources. In this presentation, statistical energy analysis is used to calculate fuselage skin vibration and interior noise levels, with the sidewall represented as a double-wall system. The results show that, in the case of an unpressurized fuselage, the acoustic transmission is dominated by the non resonant response of the structure. Extension of the results to include pressurization effects and turbulent boundary layer excitation is discussed, particular emphasis being placed on aerodynamic coincidence (Author)

**A76-38068 \*** On sound transmission into a stiffened cylindrical shell under flight conditions L R Koval (Missouri, University, Rolla, Mo) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-549* 7 p 14 refs Grant No NSG 1050

In the context of airborne noise transmission through an aircraft fuselage, a mathematical model is presented for sound transmission into a stiffened cylindrical shell. The stiffening effect of the ring frames and stringers is approximated by a 'smeared' stiffener theory which includes the eccentricity of the stiffeners. Numerical results are presented for a typical narrow-bodied jet in cruising flight. A comparison is made between noise transmission into a monocoque

shell and into a stiffened shell. The stiffeners are shown to greatly increase TL for small incidence angles, so that the effective 'window' for noise transmission is restricted to the neighborhood of normal incidence. Flow is shown to increase TL for sound waves propagating 'upstream' against the flow. Stiffeners are also shown to raise the ring frequency at which a dip in cylinder TL occurs. Limitations of the 'smeared' stiffener theory are also discussed (Author)

**A76-38069 \*** Model and full-scale large transport airframe noise J G Shearin, D J Fratello (NASA, Langley Research Center, Hampton, Va.), A J Bohn, and W D Burggraf (Boeing Commercial Airplane Co., Seattle, Wash.) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-550* 8 p

Results are presented for an airframe noise experiment intended to obtain airframe noise data of a 0.03 scale model of a large transport aircraft in a flow facility for comparison with similar airframe noise data from full scale flyover tests of the same aircraft. The test model simulated the landing and cruise configuration, including individual flap systems. Considerable noise is found to be associated with the extension of the model's leading edge flap system and to be reduced across the noise spectra when the gaps between the leading edge flaps and the leading edge of the wing are sealed. Amplitude and frequency scaling relationships are developed which correlate respective data for a variety of aircraft configurations. Normalized model landing gear noise failed to simulate full-scale data S D

**A76-38070 \*** Measurement, analysis, and prediction of aircraft interior noise J T Howlett, L H Williams, J J Catherine (NASA, Langley Research Center, Hampton, Va.), and S K Jha (Cranfield Institute of Technology, Cranfield, Beds., England) *American Institute of Aeronautics and Astronautics, Aero Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-551* 7 p 10 refs

Considerations of comfort of passengers and crew in light aircraft and helicopters indicate substantial benefits may be obtained by the reduction of interior noise levels. This paper discusses an ongoing research effort to reduce interior noise in such vehicles. Data from both field and laboratory studies for a light aircraft are presented. The laboratory data indicate that structural vibration is an efficient source of interior noise and should be considered in the reduction of interior noise. Flight data taken on a helicopter before and after installation of acoustic treatment demonstrate that over 30 dB of noise reduction can be obtained in certain portions of the spectra. However, subjective evaluations of the treated vehicle indicate that further reductions in interior noise are desirable. An existing interior noise prediction method which was developed for large jet transports was applied to study low-frequency noise in a light aircraft fuselage. The results indicate that improvements in the analytical model may be necessary for the prediction of interior noise of light aircraft (Author)

**A76-38071 #** Sound radiation from aircraft wheel-well/landing gear configurations H H Heller and W M Dobrzynski (Deutsche Forschungs und Versuchsanstalt für Luft- und Raumfahrt, Institut für Technische Akustik, Braunschweig, West Germany) *American Institute of Aeronautics and Astronautics, Aero Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-552* 10 p 12 refs

An experimental program was initiated to determine the noise radiation from landing gear wheel well configurations of large commercial aircraft. Scaled models of typical nose gears and main gears (synthesized from different type aircraft) were exposed to flow of typical landing approach speeds (up to 65 m/s) on a stationary outdoor wall jet flow facility and attached to the wings of an aerodynamically very clean glider. Landing-gear noise is composed of sound generated by the interaction of flow with the wheel-well



volume and the external gear equipment. The contribution of some dominant features of a gear (shaft, struts, actuators, doors, wheels) to the total sound signature were determined and normalized nose gear and main gear spectra developed, that predict measured full scale landing gear noise fairly well. (Author)

**A76-38072 \* #** Inflight simulation experiments on turbulent jet mixing noise. H. K. Tanna and P. J. Morris (Lockheed Georgia Co., Marietta, Ga.) *American Institute of Aeronautics and Astronautics, Aero Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-554* 11 p. 13 refs. Research supported by the Lockheed Georgia Co., Contracts No. NAS3-18540, No. F33615 73-C-2032.

The effects of aircraft forward motion on pure turbulent mixing noise from unheated jets are examined experimentally in the inflight simulation mode. Both acoustic and flow characteristics are determined by testing model-scale nozzles in an anechoic free-jet facility and a wind tunnel, respectively. Scaling laws are derived from each set of experiments and are found to be complementary. The implications are discussed in detail. In particular, it is shown that the measured reduction in noise at 90 deg to the jet axis is a pure source alteration effect. (Author)

**A76-38073 \* #** Flight effects on JT8D engine jet noise as measured in the NASA Ames 40-by 80-foot wind tunnel. F. G. Strout (Boeing Commercial Airplane Co., Seattle, Wash.) and A. Atencio, Jr. (NASA, Ames Research Center, U.S. Army, Air Mobility Research and Development Laboratory, Moffett Field, Calif.) *American Institute of Aeronautics and Astronautics, Aero Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-556* 12 p.

A JT8D 17 turbofan engine was tested in a 40 x 80 ft wind tunnel to determine flight effects on jet noise. The engine was configured as a baseline with conical nozzle, a quiet nacelle 20 lobe ejector/suppressor, and an internal mixer with conical nozzle. Tunnel off and tunnel on noise tests were conducted over a range of nozzle pressure ratios (1.2 to 2.1), primary jet velocities (275 to 550 m/s), and tunnel velocities up to 100 m/s. Aft quadrant noise data were measured by a pair of traversing microphones located on a 3 m sideline relative to the engine centerline. Unique correlations and analysis procedures were developed in order to define far field flight effects from the relatively near-field noise measurements. The ejector/suppressor experienced a significant loss of suppression relative to static measurements during flight while the internal mixer indicated a slight gain in suppression. It is concluded that the wind tunnel is a viable method for studying flight effects on engine jet noise. (Author)

**A76-38074 #** Effect of flight on the noise from a convergent nozzle as observed on the Bertin Aérotrain. P. Drevet, J. P. Duponchel, and J. R. Jacques (SNECMA, Paris, France) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-557* 16 p. 30 refs.

The effect of flight on the noise radiated by a jet exhausting from a convergent nozzle is studied experimentally on the Bertin Aerotrain propelled by a J85 engine. Data presented include subsonic and supersonic jet noise data up to a jet speed of 670 m/s and a flight speed of 82 m/s. The behaviour of shock associated noise in flight is determined through a comparison of the convergent nozzle data with some convergent-divergent nozzle data. A generalised experimental description of jet noise in flight is presented together with a theory to experiment comparison and a tentative to explain the observed discrepancies. (Author)

**A76-38075 \* #** Effects of external boundary layer flow on jet noise in flight. V. Sarohia and P. F. Massier (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.) *American*

*Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-558* 11 p. 22 refs. Contract No. NAS7 100.

The effects on jet flow of the external boundary layer flow emanating from the trailing edge of an engine cowl in flight has been shown to be the main reason for the disparity between predicted and experimental results obtained from flight measurements. Flight simulation experiments indicate that the external boundary layer flow tends to shield the jet flow in flight. This in turn modifies the jet noise source in flight and consequently the radiated noise from aircraft in flight. Close to 90 deg angle to the intake and in the forward quadrant, this study indicates that the far field jet noise and its spectrum scales approximately with the absolute jet velocity instead of the relative velocity as has been assumed in the existing prediction models. (Author)

**A76-38076 #** Noise produced by turbulent flow into a propeller or helicopter rotor. R. K. Amiet (United Technologies Research Center, East Hartford, Conn.) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-560* 11 p. 28 refs.

A method for calculating the far-field noise produced by an airfoil in rectilinear motion through a turbulent flow field is extended to the case of a rotating blade, thus giving a prediction method for a propeller or helicopter rotor with a turbulent inflow. The method incorporates accurate airfoil response functions including the effects of compressibility and noncompactness. A high frequency assumption is made in the analysis, but comparison with calculations not making this assumption indicates that the present method is accurate for frequencies above the first few rotor harmonics. Given the spectral characteristics of the turbulence, the analysis is of an absolute nature containing no adjustable constants, and gives a prediction of both the frequency spectrum and directivity of the far field noise. (Author)

**A76-38077 #** High frequency broadband rotor noise. A. R. George and Y. N. Kim (Cornell University, Ithaca, N.Y.) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-561* 11 p. 27 refs. Grant No. DAHC04 75-6 0120.

A method is developed to find the absolute spectral level of high-frequency far field sound of a rotor in terms of random load fluctuations on the rotor blades. The analysis deals with frequencies where the radiated sound spectrum is smooth, i.e., above 300 to 400 Hz for a typical helicopter. It is shown that the smooth broadband part of the spectrum corresponds to load fluctuations which are uncorrelated between blade passages and that the spectral intensities from the individual blades are additive. A point load approximation with spanwise loading corrections is used, and the blade loading spectrum is specifically derived for upwash fluctuations due to inflow turbulence. The method is compared with a more general method and published experimental data. The agreement between the two theories is excellent. The comparison with the experiments is good, although it is not clear how to estimate the increase in intensity of atmospheric turbulence as it is distorted while being drawn into the rotor. The results indicate that atmospheric turbulence is perhaps the major contribution to broadband noise in hover. (Author)

**A76 38078 #** High forward speed helicopter noise. S. E. Wright *American Institute of Aeronautics and Astronautics, Aero Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-562* 10 p. 11 refs. Research supported by the Science Research Council.

A general theory is described which deals with the discrete radiation from real source distributions in constant rectilinear motion. The theory gives finite radiation in terms of simple solutions for any acoustic multipole order and for any source speed. This theory can be used to indicate most of the essential radiation features of sources in arbitrary motion. As an example of the theory,

the radiation from distributed unsteady blade forces is considered. These sources, which contribute to helicopter noise in hover and low speed flight, are found to have at high speed, acoustic properties similar to those produced by helicopter rotors in high speed flight, including an acoustic beaming effect in the direction of source motion (Author)

**A76-38079 \* #** Development of a noncompact source theory with applications to helicopter rotors F Farassat and T J Brown (NASA, Langley Research Center, Hampton, Va) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-563* 8 p 7 refs Grant No NGR 09 010-085

A new formulation for determining the acoustic field of moving bodies, based on acoustic analogy, is derived. The acoustic pressure is given as the sum of two integrals, one of which has a derivative with respect to time. The integrands are functions of the normal velocity and surface pressure of the body. A computer program based on this formulation was used to calculate acoustic pressure signatures for several helicopter rotors from experimental surface pressure data. Results are compared with those from compact source calculations. It is shown that noncompactness of steady sources on the rotor can account for the high harmonics of the pressure system. Thickness noise is shown to be a significant source of sound, especially for blunt airfoils in regions where noncompact source theory should be applied. C K D

**A76-38080 \* #** An experimental study of helicopter rotor rotational noise in a wind tunnel A Lee, W L Harris, and S E Widnall (MIT, Cambridge, Mass) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-564* 8 p 13 refs Contract No NAS2-7684

The rotational noise of model helicopter rotors in forward flight was studied in an anechoic wind tunnel. The parameters under study were the rotor thrust (blade loading), blade number and advance ratio. The separate effects of each parameter were identified with the other parameters being held constant. The directivity of the noise was also measured. Twelve sets of data for rotational noise as a function of frequency were compared with the theory of Lowson and Ollerhead. In general, the agreement is reasonably good, except for the cases of (1) low and high disk loadings, (2) the four bladed rotor, and (3) low advance ratios. The theory always under estimates the rotational noise at high harmonics (Author)

**A76-38081 #** Near field noise of high tip speed propellers in forward flight D B Hanson (United Technologies Corp, Hamilton Standard Div, Windsor Locks, Conn) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-565* 14 p 10 refs

A near field theory is presented for the noise caused by thickness and loading of propellers operating at supersonic or high subsonic tip speeds. By use of a helical coordinate system and a source description in the stationary reference frame, mathematical singularities can be avoided altogether in the analysis. The source terms are integrated over a virtual blade area (the acoustic planform) which is constructed from locations of the blade elements at their retarded times. The acoustic planform illustrates the non compact nature of the source at high tip speed and is shown to split into two regions during supersonic operation. Theoretical waveforms and harmonic directivity are compared with existing propeller noise data up to sonic tip speed. The good agreement indicates that the assumptions of linearity are justified and that the thickness and loading source terms represent the noise generation process adequately. Shocks need not be included explicitly in the source formulation (Author)

**A76-38082 \* #** Effect of loading and rotor wake characteristics on the acoustic field of stator blades H Atassi (Notre Dame, University, Notre Dame, Ind) *American Institute of Aeronautics*

*and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-566* 7 p 9 refs Grant No NsG 3037

The generation of blade passing frequency noise due to rotor wakes interaction with the downstream stator is examined using a recent model for the unsteady aerodynamic forces developed by Goldstein and Atassi. The effects of blade geometry and loading are investigated. It is shown that at low reduced frequencies loading significantly reduces the noise level while at high frequencies loading substantially increases the sound level radiated. It is also shown that for the same loading a higher angle of attack generates more noise particularly at higher reduced frequencies. The noise level shows a quasi periodic pattern with pronounced minima and maxima as the frequency increases. These conclusions are valid for different wake models (Author)

**A76-38083 #** A study of factors affecting the broadband noise of high speed fans R B Ginder (National Gas Turbine Establishment, Farnborough, Hants, England) and D R Newby (Rolls-Royce /1971/, Ltd, Derby, England) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-567* 10 p 11 refs

Broadband noise data has been obtained from tests on a wide variety of transonic design speed fans. These fans show considerable differences in noise level at a given tip speed which are often inconsistent with trends expected from previous correlations. In particular fan loading does not appear to be of primary importance. A new correlation has been developed using rotor blade incidence and relative velocity as primary parameters. The use of incidence accounts for variations in noise between the fans and also for the effects of throttling at constant tip speed, resulting in a good collapse of data. However, the remaining scatter shows that some second order effects do exist, and these are discussed (Author)

**A76-38084 \* #** Influence of blade characteristics on axial flow compressor noise E Lumsdaine and J G Chering (Tennessee, University, Knoxville, Tenn) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-570* 11 p 28 refs Grant No NGR 43-001 134

This experimental study was initiated as a result of earlier theoretical work which found that changes in the spanwise circulation distribution can have a significant influence on noise generation for the single rotor and for rotor/stator combinations. The experimental results presented here clearly show that the rotor noise, and especially the rotor/stator interaction noise, is affected by the type of radial loading, i.e., type of twist. Other blade parameters tested for their influence on far field noise include rotor solidity, spacing between rotor and stator for twisted and untwisted blades, blade thickness, and stator chord length, radial effects on cutoff were also investigated (Author)

**A76-38085 \*** Noise comparisons of single and two stage demonstrator fans for advanced technology aircraft M F Heidmann (NASA, Lewis Research Center, Cleveland, Ohio) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-572* 12 p 15 refs

A high speed single stage and a low speed two stage fan were designed, fabricated and tested to demonstrate their predicted low noise performance for an advanced 0.85-0.90 cruise Mach number aircraft requiring a 1.8-1.9 pressure ratio fan. Acoustic tests were made with both unsuppressed and suppressed configurations. The two stage fan demonstrated that quiet fan technology developed for low-speed single stage fan is applicable to two stage designs. The unsuppressed two stage fan was 3.5 dB quieter than the high speed single stage fan at the same pressure ratio. The unsuppressed high speed single stage fan demonstrated that significant reductions in inlet noise can be achieved from the sonic blockage caused by supersonic flow in the rotor blading. Both fans demonstrated suppressed inlet noise levels with treated sonic inlets that met

advanced technology goals. Suppressed aft noise levels did not meet expectations for either fan. The aft noise problem is attributed to both excessive source noise and ineffective treatment performance. (Author)

**A76-38086 \* #** Acoustic and aerodynamic effects of rotor pitch angle for a variable-pitch, 6-foot diameter fan stage. R P Woodward and F W Glaser (NASA, Lewis Research Center, Cleveland, Ohio) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-573* 12 p 7 refs

An externally driven, 1.2 pressure ratio full scale fan stage with an adjustable pitch rotor was tested in an outdoor facility at the Lewis Research Center. Rotor pitch angles resulting in minimum sideline perceived noise levels are defined as a function of stage thrust. Thrust corrected fan noise variations are examined for operation at constant thrust, rotor tip speed, and stage work coefficient. At constant stage thrust, reducing the rotor pitch angle below design values increased the fan noise with the greatest change occurring in the blade passing tone level. At constant fan speed the minimum noise occurred at a particular rotor pitch angle, which was not the minimum thrust condition. With constant stage work coefficient, rear quadrant noise increased at above design speed conditions. (Author)

**A76-38087 \* #** Modal structure inferred from static far-field noise directivity. A V Saule (NASA, Lewis Research Center, Cleveland, Ohio) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-574* 9 p 15 refs

Turbofan noise directivity calculated for two directivity models (equal modal amplitude and equal modal power or energy) was compared with experimental blade passing frequency data from two fans at 60 and 90 percent speeds. Experimental data indicated similar directivity patterns which were well represented by a single average data curve. Calculated points using the equal amplitude model showed over-prediction near the fan axis and near the 90-degree position. Calculated points using the equal power model showed a very good match with the average data lending support to theory of equipartition of modal power from a random source such as the interaction of the rotor with inlet flow distortion. The equal modal power model also gave good agreement with individual data points. (Author)

**A76-38088 \* #** Noise reduction from the redesign of a fan stage to minimize stator lift fluctuations. J H Dittmar and R P Woodward (NASA, Lewis Research Center, Cleveland, Ohio) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-576* 9 p 10 refs

An existing fan stage, redesigned to reduce stator lift fluctuations, was acoustically tested for reduced noise generation. The lift fluctuations on the stator were reduced by increasing the stator chord, adjusting incidence angles, and by adjusting the rotor velocity diagrams. The experiments showed significantly reduced broadband noise levels in the middle to high frequencies. Blade passage tone power was not reduced, but decreases in the harmonics were observed. Aerodynamic improvements in both performance and efficiency were obtained. (Author)

**A76-38089 #** Combustion noise characteristics of a can-type combustor. B N Shivashankara and R W Crouch (Boeing Commercial Airplane Co., Seattle, Wash.) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-578* 10 p

The effects of flow rate, combustor temperature rise, inlet temperature, nozzle exit diameter, and duct length on spectral content, directionality, radiated sound power, and thermoacoustic efficiency are experimentally deduced using an 8-in diameter combustor. Even at a high exit velocity of 900 fps, the combustor-on-

noise is seen to dominate jet noise. Internal and far field spectra are similar below 1000 Hz (broadband with spikes at longitudinal duct resonance frequencies). Directionality is weak except at exit velocities in excess of 550 fps. At a given nozzle exit temperature and diameter, the internal overall sound pressure levels appear to be linearly related to the far field levels. The thermoacoustic efficiencies vary from one millionth to one ten thousandth. (Author)

**A76-38091 #** The radiation of plane-wave duct noise from a jet exhaust, statically and in flight. R A Pinker and W D Bryce (National Gas Turbine Establishment, Farnborough, Hants., England) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-581* 9 p 12 refs

In order to understand the radiation of noise from aircraft engine exhausts, model experiments have been conducted to determine the far field directivity of low frequency internal noise over a range of jet velocities and temperatures. The internal noise is seen to be increasingly convected in the downstream direction as the jet velocity is increased, without any evidence of jet resonance phenomena. Further experiments, surrounding the jet by a co-flowing airstream, have enabled the effect of flight on plane-wave internal noise to be quantified. A recently-developed theory is shown to agree closely with both the static and the flight results obtained using a cold jet. (Author)

**A76-38093 \* #** An investigation of possible causes for the reduction of fan noise in flight. B K Hodder (NASA, Ames Research Center, U.S. Army, Air Mobility Research and Development Laboratory, Moffett Field, Calif.) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-585* 12 p 15 refs

An experimental investigation of the impact on fan tone noise generation of several engine inflow distortions found in conventional static testing has been made. Inflow distortions examined included the ground vortex, atmospheric turbulence, and test stand structure interference. This work was undertaken to help explain results from noise measurements made on modern turbofan engines which show lower fan tone levels in flight at the blade-passing frequency than are predicted from static measurements. The results indicate that the ground vortex can greatly increase noise at the blade-passing frequency. A special inlet was designed to examine the effects of atmospheric turbulence. Use of this inlet reduced the variability of the sound pressure level at the blade passing frequency, and the results were similar to those found in flight. (Author)

**A76-38094 #** Sonic boom propagation through nonuniform flow fields. W Whitlow, Jr and W L Harris (MIT, Cambridge, Mass.) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-586* 7 p 15 refs. Research supported by the Massachusetts Institute of Technology.

Sonic boom pressure profiles and curvature have been measured in a variable flow field produced in a wind tunnel. The variable flow field has been generated by utilizing a centered expansion. The sonic boom curvature data compares favorably with the predictions made by two dimensional theory. Trends in peak-to-peak pressure perturbations, impulse, wave width, and maximum over pressure have been observed. A two probe system is used for pressure measurements. (Author)

**A76-38095 \* #** Nonlinear sonic boom analysis including the asymmetric effects. A Ferri, L Ting, and R W Lo (New York University, New York, N.Y.) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-587* 9 p 12 refs. Grant No. NGL 33 016 119.

A numerical program is developed which takes into account the nonlinear effects of high Mach number, the entropy change across the shock, the entropy and enthalpy variations in the atmospheric

layer and the gravitational effect. The program differs from the existing ones by accounting for non axisymmetric terms. The asymmetry can be caused by the geometry of the body, the lift and also the fact that the variations in the atmospheric layer are two dimensional. Numerical results demonstrate that the influence of these asymmetric effects tends to lower the pressure signature.

(Author)

**A76-38096 #** A wind tunnel investigation of vortex refraction effects on aircraft noise propagation. R W Jeffery, E G Broadbent, and A F Hazell (Royal Aircraft Establishment, Farnborough, Hants, England). *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76 588* 10 p 8 refs

One possible method for reducing aircraft fly over noise is to site the engines so that the wing vortex can refract sound away from the ground. A series of experiments were carried out in the RAE 24 ft wind tunnel using a model of the HP 115 slender delta research aircraft, which produced a strong leading edge vortex when set at incidence. The engine noise was simulated by a Hartmann whistle mounted above the engine intake. The results are compared with a theoretical prediction based on ray theory and a simplified representation of the wing vortex structure.

(Author)

**A76-38168 \* #** The NASA Pollution-Reduction Technology Program for small jet aircraft engines - A status report. J S Fear (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif, July 26-29, 1976, AIAA Paper 76-616* 13 p

A three phase experimental program is described which has the objective of enabling EPA Class T1 jet engines to meet the 1979 EPA emissions standards. In Phase I, three advanced combustor concepts, designed for the AiResearch TFE 731-2 turbofan engine, were evaluated in screening tests. Goals for carbon monoxide and unburned hydrocarbons were met or closely approached with two of the concepts with relatively modest departures from conventional combustor design practices. A more advanced premixing/prevaporizing combustor, while appearing to have the potential for meeting the oxides of nitrogen goal as well, will require extensive development to make it a practical combustion system. Smoke numbers for the two combustor concepts which will be carried forward into Phase II of the program were well within the EPA smoke standard. Phase II, Combustor Engine Compatibility Testing, which is in its early stages, and planned Phase III, Combustor Engine Demonstration Testing, are also described.

(Author)

**A76-38169 #** An experimental investigation on loss reduction in small guide vanes. W Tabakoff (Cincinnati, University, Cincinnati, Ohio) and W Hosny. *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif, July 26-29, 1976, AIAA Paper 76-617* 9 p 13 refs. Grant No. DAHCO4 69 C 0016

Various techniques for secondary losses reduction in turbo machine cascades are examined. Preliminary findings concerning a new technique for controlling the secondary flow and its losses in a nozzle guide vane are presented in terms of the total pressure losses for three cases: a guide vane with an inlet flow velocity profile that has appreciable end wall boundary layers, a guide vane with an inlet flow velocity profile which has a mid span wake, and a guide vane with annular splitter ring attached to the nozzle blade leading edge. It is shown that end wall contouring is an effective means to reduce secondary losses in small turbine guide vanes. Additional reduction in the total losses can be attained by using an annular splitter at the guide vane entrance region.

S D

**A76-38170 #** Development of a new class of engine - The small turbofan. T K Wills (USAF, Aeronautical Systems Div.,

Wright Patterson AFB, Ohio) and E P Wise (Williams Research Corp., Walled Lake, Mich.). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif, July 26-29, 1976, AIAA Paper 76 618* 17 p

A small two spool turbofan engine series has been developed by the Williams Research Corporation, Walled Lake, Michigan, that covers a broad spectrum of applications in the 600 lb thrust area, particularly those requiring high specific thrust and low fuel consumption. The latest models of the engine have been specifically developed for cruise missiles. It is shown that highly efficient, though basically simple, 600 lb thrust class turbofan engines can be developed and produced to satisfy fuel efficient requirements previously considered possible only through use of much larger engines. The spectrum of flight vehicles thereby made practical is greatly expanded in the very small, high performance areas.

(Author)

**A76-38171 #** Where do we go from here. The non-propulsive small gas turbine. W B Harper and S W Mitnik (AiResearch Manufacturing Company of Arizona, Phoenix, Ariz.). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif, July 26-29, 1976, AIAA Paper 76 619* 6 p 9 refs

The non-propulsive gas turbine has acquired a jack of all trades role in the power production industry. Its end uses have ranged from generator sets, to ground carts, commercial aircraft auxiliary power units, to military aircraft secondary power systems. In each of these applications, the end user has consistently clamored for smaller sizes, reduced specific fuel consumption, and lower costs. This paper will attempt to place some perspective on the forward movement of the nonpropulsive small gas turbine under these three opposing forces.

(Author)

**A76-38172 #** An aerobatic PT6. H J Martin (Pratt and Whitney Aircraft of Canada, Ltd., Longueuil, Quebec, Canada). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif, July 26-29, 1976, AIAA Paper 76-620* 8 p

A lubrication system has been introduced into the Pratt and Whitney PT6 turboprop engine to allow the engine to be subjected to inverted flight and various other aerobatics. A brief outline is given of the original design and its successful flight followed by an account of methods used, problems encountered, and results achieved in developing the system to production status. Some restraint is imposed on the design by the fact that the PT6 main oil pump is inside the integral oil tank, whose walls comprise major structural members of the engine framework.

(Author)

**A76-38174 \*** Nozzle and wing geometry effects on OTW aerodynamic characteristics. U von Glahn and D Groesbeck (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif, July 26-29, 1976, AIAA Paper 76-622* 15 p 6 refs

The effects of nozzle geometry and wing size on the aerodynamic performance of several 5:1 aspect ratio slot nozzles are presented for OTW configurations. Nozzle geometry variables include roof angle, sidewall cutback, and nozzle chordwise location. Wing variables include chord size, and flap deflection. Several external deflectors also were included for comparison. The data indicate that good flow turning may not necessarily provide the best aerodynamic performance. The results of the study suggest that a variable exhaust nozzle geometry offers the best solution for a viable OTW configuration.

(Author)

**A76-38175 \* #** USB environment measurements based on full-scale static engine ground tests. M B Sussman, D L Harkonen, and J B Reed (Boeing Co., Seattle, Wash.). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif, July 26-29, 1976,*

**AIAA Paper 76-624 8 p** NASA supported research

Flow turning parameters, static pressures, surface temperatures, surface fluctuating pressures and acceleration levels were measured in the environment of a full scale upper surface blowing (USB) propulsive-lift test configuration. The test components included a flightworthy CF6 50D engine, nacelle and USB flap assembly utilized in conjunction with ground verification testing of the USAF YC 14 Advanced Medium STOL Transport propulsion system. Results, based on a preliminary analysis of the data, generally show reasonable agreement with predicted levels based on model data. However, additional detailed analysis is required to confirm the preliminary evaluation, to help delineate certain discrepancies with model data and to establish a basis for future flight test comparisons. (Author)

**A76-38188 #** Life cycle fuel consumption of commercial turbofan engines. W R Beyerly and J G Sweeney (United Technologies Corp., Commercial Products Div., East Hartford, Conn.) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-645* 7 p

Escalating fuel costs together with recently established national energy conservation goals have led to a new awareness of the importance of minimizing fuel consumption throughout the life cycle of an aircraft engine. This paper presents an overview and analysis of fuel consumption variations for Pratt & Whitney Aircraft JT3D, JT8D and JT9D engines through successive periods of on the wing service with emphasis on the retention of engine performance through minor maintenance and major overhaul actions. Also discussed are methods of minimization of the performance loss through operational and functional procedures and through proper selection of design criteria. (Author)

**A76-38189 #** Maintenance of performance in service operation experience on the Rolls-Royce RB 211-22B engine. A D Jones and B J Collins (Rolls-Royce /1971/, Ltd., Derby, England) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-648* 6 p

The sensitivity of cruise specific fuel consumption due to deterioration in component performance has been assessed for various engine cycle parameters. The data compares today's large bypass ratio engines with the previous generation of jet engines. With this knowledge, certain design features were incorporated into the RB 211 such as to minimize the performance deterioration during service operation. These features are examined and discussed in relation to their effect on individual component performance and hence the overall engine performance. In service operational data has been measured and analyzed such as to assess the change in the various components, and to introduce rework procedures and modifications to eliminate or minimize the performance deterioration. (Author)

**A76-38190 #** Performance depreciation of some military turbofan engines. F L Cavanaugh (USAF, Aeronautical Systems Div., Wright Patterson AFB, Ohio) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-649* 9 p

It is an accepted fact that the performance of a turbofan engine will depreciate with operating time. The magnitude of this loss in performance depends on many variables. These include type of operation, engine cycle, operating atmosphere, and control mode. Performance deterioration of some advanced turbofan military engines is discussed. Component deterioration as a function of time is presented from both field service and factory development engine data. Various types of control mode philosophies are discussed along with their effect on engine performance and stability characteristics under a deteriorated condition. Engine computer simulations are used to extrapolate an engine's behavior with deterioration at selected altitude/Mach number conditions. Data are presented to

show the effects the various control modes have on an engine's performance and stability with operating time. (Author)

**A76-38191 #** Analog vs digital engine control tradeoff considerations. R P Wanger (General Electric Co., Aircraft Engine Group, Cincinnati, Ohio) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-650* 6 p 5 refs

This paper describes the tradeoff between analog and digital electronics for future aircraft engine controls. Analog electronics have been applied for control of engine fuel flows and variable geometries. An engine control complexity criteria can be defined above which digital electronics is the preferred computational choice. The development of digital large scale integration (LSI) has reduced the complexity level at which digital electronics may be advantageously applied. Digital electronics enhances the capability of the engine control to receive thrust commands from the aircraft and to transmit engine data to the aircraft. The digital engine control permits implementation of modern multivariable approaches to control. (Author)

**A76-38203 #** Vortex burning and mixing (Vorbix) augmentation system. R S Reilly and S J Markowski (United Technologies Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-678* 8 p 13 refs Contract No. N00019-72-C-0612

Results are presented for an experimental program in which the feasibility of applying high rate swirl combustion techniques in an advanced turbofan augmentor was evaluated. The rig tests were conducted at sea level static conditions of inlet temperature, Mach number, and temperature rises, but at subatmospheric pressure levels. In lieu of flameholders and zoned spray bars, the concept employed a pilot and vortex generators in conjunction with a simple two zone fuel system to achieve rapid fuel vaporization, mixing, and combustion. System efficiencies of approximately 90% at an augmentor length reduction of 28% were achieved at nominal levels of inlet Mach number. A dry pressure loss level consistent with current augmented turbofan cycle requirements was also achieved. Modulation was continuous over the entire operating range (fuel/air ratio between 0.0075 and 0.055) with excellent stability and a flat efficiency-fuel/air characteristic. Both a cost reduction through control system simplicity and a significant thrust advantage due to higher augmented efficiencies result when an augmentor of this type, which is called a Vorbix augmentor, is installed in a current turbofan engine. (Author)

**A76-38205 #** A combustion model for low frequency instability in turbofan augmentors. R C Ernst (United Technologies Corp., Pratt and Whitney Aircraft Group, West Palm Beach, Fla.) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-680* 8 p 11 refs Contracts No. F33615-76-C-2023, No. F33615-76-C-2024

Low frequency instability problems have historically hampered the development process of turbofan augmentors. The low frequency nature of the instability precludes use of classical acoustic suppression techniques. The instability level responds to alterations in the flameholder of the low inlet temperature portion of the augmentor. A combustion model is presented for the process of flame stabilization at inlet air temperatures below the fuel boiling temperature. The influence of flameholder geometry on the flame stability process and on the combustion driving potential for low frequency instability is discussed. (Author)

**A76-38206 #** A method for the prediction of crack initiation in combustion chamber liners. W H Vogel, R W Soderquist, and B C Schlein (United Technologies Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers,*

*Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-681* 8 p 6 refs Contract No F33615 75 C 2057

An analytical procedure for predicting the crack initiation life of jet engine combustion chamber liners is presented. Sample calculations using the procedure are made and correlated against representative engine and test rig data. The analysis employs the Strain Range Partitioning Method, proposed by S. S. Manson, et al., to determine the Low Cycle Fatigue and Creep damage components. A procedure for estimating plastic strain range and creep strain per cycle is presented and life estimates are made using the above in combination with a linear cumulative damage summation of the LCF and creep damage components. (Author)

**A76-38207 #** **A quasi-three-dimensional calculation procedure for predicting the performance and gaseous emissions of gas turbine combustors** J. W. Sanborn, R. S. Reynolds, and H. C. Mongia (Air Research Manufacturing Company of Arizona, Phoenix, Ariz.) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-682* 12 p 23 refs Research sponsored by the Garrett Corp.

An efficient calculation procedure that utilizes both flow and kinetic models to predict the performance and emissions from a variety of gas turbine combustors is presented. The calculation method combines both detailed aerodynamic predictions to describe the flow field, and a multi-step reaction mechanism to simulate the combustion process associated with gas turbine combustors. This procedure requires a minimal amount of empiricism and, therefore, is quite flexible and applicable to a number of combustor configurations. This procedure has been used to study several gas turbine combustors and the results are presented for both two dimensional and three-dimensional modeling procedures. Based on the studies, it is evident that the three-dimensional analysis is necessary when dealing with highly three dimensional effects such as flow in the vicinity of primary and dilution jets, and to study advanced technology high heat release combustors. (Author)

**A76-38218 \* #** **A method of distortion pattern synthesis for high response data screening** R. W. King (United Technologies Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.) and H. E. Neumann (NASA, Lewis Research Center, Cleveland, Ohio) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-704* 8 p 5 refs

An empirically derived method of estimating maximum levels of instantaneous inlet total pressure distortion from steady state measurements is presented. The estimation procedure uses steady state total pressure and root mean square turbulent pressure data measurements to synthesize instantaneous distortion patterns. The synthesis method is tailored to intensify distortion patterns in a manner consistent with the characteristics of the particular index to be used in evaluating inlet/engine compatibility. The maximum expected value of distortion, a statistically determined function of the length of time of inlet operation, is used to constrain the amount of pattern intensification. Comparison with an independent set of data is presented for verification of the synthesis method. (Author)

**A76-38219** **Determination of maximum expected instantaneous distortion patterns from statistical properties of inlet pressure data** D. L. Motyka (United Technologies Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-705* 6 p 11 refs

An inexpensive and time saving procedure is proposed which uses random numbers to synthesize instantaneous inlet distortion in turbine engines from statistical properties of inlet pressure data. The statistical properties include amplitude probability density, standard deviation, mean, and power spectral density. Determination of the statistical properties of each pressure can be done with simple meter

readings. If more precision is desired a spectral analyzer may be used. Not only did the levels of synthesized distortion factors agree well with the test data, but pattern comparisons were excellent. It is concluded that maximum instantaneous distortion patterns can be accurately synthesized by random number processing and that power spectral density variations influence the distribution of extreme values of the distortion factors versus sampling times. S. D.

**A76-38232 #** **Potential and problems of premixed combustors for application to modern aircraft gas turbine engines** P. Goldberg, I. Segalman, and B. Wagner (United Technologies Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-727* 10 p

An engine test program was conducted to investigate gaseous pollutant emissions reductions achievable with a premixed combustor in a high pressure ratio aircraft gas turbine engine. Design point emissions for the premixed combustor were well below those generated by a conventional, production type combustor tested in the same JT9D engine. THC and CO at idle conditions were reduced by approximately 90% and NO<sub>x</sub> at sea level take off conditions by approximately 50%. Smoke number at climb conditions was reduced by approximately 70%. This testing also has uncovered several areas requiring further innovation and development, namely off design combustion efficiency, a complex fuel management system, and autoignition in premixing passages. (Author)

**A76-38233 \*** **Stagnation region gas film cooling for turbine blade leading edge applications** D. W. Luckey, D. K. Winstanley, G. J. Hanus, and M. R. L'Ecuier (Purdue University, West Lafayette, Ind.) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-728* 11 p 18 refs Contract No N00014 75 C 0873, Grant No. NGR 15-005 147

An experimental investigation was conducted to model the film cooling performance for a turbine vane leading edge using the stagnation region of a cylinder in cross flow. Experiments were conducted with a single row of spanwise angled coolant holes for a range of the coolant blowing ratio with a freestream to wall temperature ratio of about 2.1 and a Reynolds number of 170,000, characteristic of the gas turbine environment. Data from local heat-flux measurements are presented for coolant hole injection angles of 25, 35, and 45 deg with the row of holes located at three positions relative to the stagnation line on the cylinder. Results show the spanwise (hole to hole) variation of heat-flux reduction due to film cooling and indicate conditions for the optimum film cooling performance. (Author)

**A76-38234 \*** **Ceramic thermal-barrier coatings for cooled turbines** C. H. Liebert and F. S. Stepka (NASA, Lewis Research Center, Cleveland, Ohio) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-729* 10 p 11 refs

Ceramic thermal barrier coatings on hot engine parts have the potential to reduce metal temperatures, coolant requirements, cost, and complexity of the cooling configuration, and to increase life, turbine efficiency and gas temperature. Coating systems consisting of a plasma sprayed layer of zirconia stabilized with either yttria, magnesia or calcia over a thin alloy bond coat have been developed, their potential analyzed and their durability and benefits evaluated in a turbojet engine. The coatings on air cooled rotating blades were in good condition after completing as many as 500 two minute cycles of engine operation between full power at a gas temperature of 1644 K and flameout, or as much as 150 hours of steady-state operation on cooled vanes and blades at gas temperatures as high as 1644 K with 35 start and stop cycles. On the basis of durability and processing cost, the yttria stabilized zirconia was considered the best of the three coatings investigated. (Author)

**A76-38235** # Three applications of Monte Carlo simulation to the development of the F100 turbofan engine R B Abernethy and J C Sammons (United Technologies Florida Research and Development Center, West Palm Beach, Fla) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif, July 26-29, 1976, AIAA Paper 76-731* 5 p

Monte Carlo simulation was applied to three problems associated with engine failure in the development of the F100 turbofan engine. These three applications were: (1) selection of the best techniques for trimming the fuel control, (2) analysis of the low cycle fatigue life of a turbine disk, and (3) prediction of turbine blade failure due to resonant vibration. B J

**A76-38236** # Normal modes vibration analysis of the JT9D/747 propulsion system J L White (Boeing Commercial Airplane Co., Seattle, Wash.) and E S Todd (United Technologies Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif, July 26-29, 1976, AIAA Paper 76-732* 5 p 6 refs

Results obtained from an exploratory program related to the structural integration of modern aircraft propulsion systems are presented. The rationale behind cooperative analyses of engine/airframe installations is discussed and is followed by a description of the procedure used to perform an integrated vibration analysis of a representative configuration. The process through which a comprehensive finite element mathematical model of the JT9D/747 installation was assembled and reduced to a manageable size for extraction of natural frequencies and mode shapes is outlined. Evaluation of the model by correlation with available test results is described. (Author)

**A76-38237** # Effect of F 15 aircraft induced aerodynamic loads on the evolution of the F100 balanced beam nozzle G A Bonner (United Technologies Corp., Pratt and Whitney Aircraft Group, West Palm Beach, Fla) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif, July 26-29, 1976, AIAA Paper 76-733* 5 p 8 refs

The basic configuration of the balanced beam nozzle is presented. Components are identified and their function discussed. The two basic convergent section actuation system load cases that result from combined internal and external pressure distributions are presented. The kinematics of the divergent section, and the resulting exit area ratio schedules are indicated. An analysis of the effect of F 15 aircraft induced aerodynamic loads on the areas of the F100 balanced beam nozzle, where the evolution of the mechanical design was significantly impacted by these loads, is presented. Possible future evolution of the design resulting from different aircraft installations is suggested. (Author)

**A76-38238** DC 10 composite acoustic inlet structural verification program W R Dunbar (Douglas Aircraft Co., Long Beach, Calif) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif, July 26-29, 1976, AIAA Paper 76-734* 8 p

A program was undertaken to determine the structural suitability of a composite acoustic inlet for the DC-10 wing engine. Airframe and mission structural requirements for the inlet were determined. A flightworthy prototype panel was designed, fabricated, and tested. Mechanical properties were determined in the laboratory. The general durability and resistance to sonic fatigue were determined by over 250 hours of combined ground and flight testing in front of a CF6 engine. Blade fragment penetration resistance tests were conducted. (Author)

**A76-38247** # Apsicost - Model and method for turbine engine design to life cycle cost W Q Wagner and C B Pheatt (Teledyne CAE, Toledo, Ohio) *American Institute of Aeronautics*

*and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif, July 26-29, 1976, AIAA Paper 76-750* 7 p 5 refs. Contract No. F33657-76-C-0606

An engineering method has been developed to facilitate designing propulsion turbine engines to achieve life cycle cost objectives. The approach includes a computerized model, which structures the contribution of each engine design discipline. The analytical technique consists of establishing a baseline life cycle cost, derived from aircraft mission, performance and deployment definition. Design iterations are then evaluated for cost/benefit impact with respect to the baseline. A hypothetical aircraft and engine program is evaluated to illustrate the course of an analysis which encompasses the conventional and aircraft related costs of propulsion engine ownership. (Author)

**A76-38248** # Joint AF/industry engine LCC methodology J R Kline and D S Williams (USAF, Wright Patterson AFB, Ohio) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif, July 26-29, 1976, AIAA Paper 76-751* 5 p

A Life Cycle Cost (LCC) methodology has been developed to aid both Air Force and Industry in facilitating effective LCC related communications between the government and industry, and in assuring that source selection decisions are based on consistent and logical criteria. The methodology utilizes an accounting type model which examines specific engine cost drivers in RDT&E, production and operations/support, and also employs specific ground rules for the application of the model. The designed use for this methodology is to provide engine LCC discrimination at source selection on all future engine contracts. The expected results are a better understanding of the LCC criteria by all vendors and a more accurate reflection of the Air Force desire for low LCC engines. (Author)

**A76-38249** # Engine life cycle cost W B Sinner (General Electric Co., Aircraft Engine Group, Evendale, Ohio) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif, July 26-29, 1976, AIAA Paper 76-754* 11 p

This paper discusses the results from a study of engine subsystem life cycle cost (LCC) and engine contribution to various type aircraft systems LCC. The development and acquisition phases of LCC are considered with emphasis on operating and support (O & S) elements. The study objectives were to determine the major opportunities for reducing LCC and to provide baseline data for improved forecasting of new engine LCC. The relative values of LCC elements for two contrasting engine types are discussed, and the effects of recent abnormal fuel price increases are explored. The system LCC and engine contributions are presented for a fighter, a helicopter, and a transport, and summary data are included for all aircraft types studied. Analysis of the data indicates that fuel and maintenance (labor and material) are the only significant targets for engine O & S cost reduction. Maintenance and fuel are also the significant targets for system O & S cost reduction, even for helicopters, where crew costs overshadow fuel cost. (Author)

**A76-38250** \* Scramjet integration on hypersonic research airplane concepts J P Widner, W J Small, and J A Penland (NASA, Langley Research Center, Hampton, Va) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif, July 26-29, 1976, AIAA Paper 76-755* 10 p 9 refs

Several rocket boosted research airplane concepts were evaluated with a research scramjet engine to determine their potential to provide research on critical aspects of airframe integrated hypersonic systems. Extensive calculations to determine the force and moment contributions of the scramjet inlet, combustor, nozzle, and airframe were conducted to evaluate the overall performance of the combined engine/airframe system at hypersonic speeds. Results of both wind tunnel tests and analysis indicate that it is possible to develop a research airplane configuration that will cruise at hypersonic speed.

on scramjet power alone, and will also have acceptable low speed aerodynamic characteristics for landing (Author)

**A76-38251 \* #** Results of the pollution reduction technology program for turboprop engines E J Mularz (NASA, Lewis Research Center, U S Army, Air Mobility Research and Development Laboratory, Cleveland, Ohio) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif, July 26-29, 1976, AIAA Paper 76-760* 9 p 5 refs Contract No NAS3-18561

A program was performed to evolve and demonstrate advanced combustor technology aimed at achieving the 1979 EPA standards for turboprop engines (Class P2) The engine selected for this program was the 501-D22A turboprop manufactured by Detroit Diesel Allison Division of General Motors Corporation Three combustor concepts were designed and tested in a combustor rig at the exact combustor operating conditions of the 501-D22A engine over the EPA landing-takeoff cycle Each combustor concept exhibited pollutant emissions well below the EPA standards, achieving substantial reductions in unburned hydrocarbons, carbon monoxide, and smoke emissions compared with emissions from the production combustor of this engine Oxides of nitrogen emissions remained well below the EPA standards, also (Author)

**A76-38252 \* #** The pollution reduction technology program for can-annular combustor engines - Description and results R Roberts, A J Fiorentino (United Technologies Corp, Pratt and Whitney Aircraft Div, East Hartford, Conn), and L Diehl (NASA, Lewis Research Center, Combustor Technology and Research Section, Cleveland, Ohio) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif, July 26-29, 1976, AIAA Paper 76-761* 11 p 10 refs Contract No NAS3 18548

Pollutant reduction and performance characteristics were determined for three successively more advanced combustor concepts Program Element I consisted of minor modifications to the current production JT8D combustor and fuel system to evaluate means of improved fuel preparation and changes to the basic airflow distribution Element II addressed versions of the two staged Vorbix (vortex burning and mixing) combustor and represented a moderate increase in hardware complexity and difficulty of development The concept selected for Element III employed vaporized fuel as a means of achieving minimum emission levels and represented the greatest difficulty of development and adaptation to the JT8D engine Test results indicate that the Element I single stage combustors were capable of dramatic improvement in idle pollutants The multistage combustors evaluated in Program Elements II and III simultaneously reduced CO, THC and NOx emissions, but were unable to satisfy the current 1979 EPA standards (Author)

**A76-38253 \* #** Low pollution combustor designs for CTOL engines - Results of the Experimental Clean Combustor Program R Roberts, A Peduzzi (United Technologies Corp, Pratt and Whitney Aircraft Div, East Hartford, Conn), and R W Niedzwiecki (NASA, Lewis Research Center, Cleveland, Ohio) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif, July 26-29, 1976, AIAA Paper 76-762* 15 p 9 refs Contracts No NAS3-16829, No NAS3-18544, No NAS3-19447

The NASA/Pratt & Whitney Aircraft Experimental Clean Combustor Program is a multi-year, major contract effort Primary program objectives are the generation of combustor technology for development of advanced commercial CTOL engines with lower exhaust emissions than current aircraft and demonstration of this technology in a full-scale JT9D engine in 1976 This paper describes the pollution and performance goals, Phase I and II test results, and the Phase III combustor hardware, pollution sampling techniques, and test plans Best results were obtained with the Vorbix concept which employs multiple burning zones and improved fuel preparation and distribution Substantial reductions were achieved in all pollutant categories, meeting the 1979 EPA standards for NOx, THC,

and smoke when extrapolated to JT9D cycle conditions The Vorbix concept additionally demonstrated the capability for acceptable altitude relight and did not appear to have unsolvable durability or exit temperature distribution problems (Author)

**A76-38254 \* #** Results of the NASA/General Electric Experimental Clean Combustor Program C C Gleason (General Electric Co, Cincinnati, Ohio) and R W Niedzwiecki (NASA, Lewis Research Center, Cleveland, Ohio) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif, July 26-29, 1976, AIAA Paper 76-763* 14 p 9 refs

The NASA/General Electric Experimental Clean Combustor Program is a multi year, major contract effort Primary program objectives are the generation of technology for development of advanced commercial CTOL engines with lower exhaust emissions than current aircraft and, demonstrations of this technology in a full-scale CF6 50C engine in 1976 This paper describes pollution and performance goals, Phase I and II test results and Phase III hardware, pollution sampling techniques and test plans Pollution results are presented in emission index and Environmental Protection Agency 1979 Standard Parameters (EPAP) Best results were obtained with a double annular combustor concept This concept, which incorporates multistage burning, produced EPAP values extrapolated to CF6 50C engine conditions for CO, HC, and NOx of 3.3, 0.3 and 4.5, respectively These represent respective CO, HC and NOx percentage reductions of 69, 93 and 42%, compared to current CF6 50 engine values The combustor also met development engine performance requirements (Author)



## STAR ENTRIES

**N76-26145\*#** National Aeronautics and Space Administration  
Ames Research Center Moffett Field Calif  
**PRELIMINARY MEASUREMENTS OF AIRCRAFT AIR-  
FRAME NOISE WITH THE NASA CV-990 AIRCRAFT**  
Kenneth C White Paul L Lasagna, and Terrill W Putnam Jan  
1976 18 p refs  
(NASA-TM-X-73116 A-6506) Avail NTIS HC \$3 50 CSCL  
01A

Flight tests were conducted in a CV-990 jet transport with engines at idle power to investigate aircraft airframe noise Test results showed that airframe noise was measured for the aircraft in the landing configuration The results agreed well with the expected variation with the fifth power of velocity For the aircraft in the clean configuration it was concluded that airframe noise was measured only at higher airspeeds with engine idle noise present at lower speeds The data show that landing gear and flaps make a significant contribution to airframe noise Author

**N76-26146\*#** National Aeronautics and Space Administration  
Ames Research Center Moffett Field Calif  
**WIND TUNNEL INVESTIGATION OF NACELLE-AIRFRAME  
INTERFERENCE AT MACH NUMBERS OF 0.9 TO  
1.4 - PRESSURE DATA, VOLUME 1**  
Daniel P Bencze Feb 1976 440 p refs  
(NASA-TM-X-73149 A-4982-Vol-1) Avail NTIS HC \$11 75  
CSCL 01A

Detailed interference force and pressure data were obtained on a representative wing-body nacelle combination at Mach numbers of 0.9 to 1.4 The model consisted of a delta wing-body aerodynamic force model with four independently supported nacelles located beneath the wing-body combination The model was mounted on a six component force balance, and the left hand wing was pressure instrumented Each of the two right hand nacelles was mounted on a six component force balance housed in the thickness of the nacelle while each of the left hand nacelles was pressure instrumented The primary variables examined included Mach number angle of attack nacelle position and nacelle mass flow ratio Nacelle axial location relative to both the wing-body combination and to each other was the most important variable in determining the net interference among the components Author

**N76-26149+** Transportation Systems Center Cambridge Mass  
**AIRCRAFT WAKE VORTICES - AN ANNOTATED BIBLIOG-  
RAPHY (1923-1975) Final Report**  
J N Hallock Jan 1976 312 p refs  
(AD-A023415/3 DOT-TSC-FAA-76-4 FAA-RD-76-43) Avail  
NTIS HC \$9 75 CSCL 20/4

An annotated bibliography is presented which consists of 570 abstracts of publications on aircraft wake vortices The material is arranged alphabetically by year of publication and covers the time period through 1975 Experimental and theoretical articles are included The formation structure motion and decay of vortices and their effect on penetrating aircraft are considered Author

**N76-26151** California Inst of Tech Pasadena  
**A STUDY OF THE TRAILING VORTICES BEHIND A RING  
WING Ph D Thesis**  
Kwasi Kete Bofah 1975 174 p

Avail Univ Microfilms Order No 76-14247

The flow field of a laminar vortex wake behind a ring wing was investigated Experiments were conducted in the GALCIT Low Speed Water Channel using laser Doppler velocimetry techniques to measure vertical and axial velocity components in the trailing vortex wake A thin cylindrical ring wing model was tested at various axial angles of attack and free stream velocities Velocity profiles were measured at several downstream stations from the trailing edge to 45 wing diameters downstream The inviscid roll-up of the trailing vortex sheet shed by a ring wing was numerically examined A line vortex representation was used to calculate the evolution of the initially cylindrical vortex sheet The vortex sheet was found to distort in shape and then smoothly roll up into a pair of doubly connected spirals whose centers originate from approximately the center of gravity of vorticity in the upper quadrants of the ring wings circular trailing edge (This origin is at an angle of 38 deg measured from the horizontal wing diameter) The experimental and flow visualization results are consistent with the numerical data and show that a pair of counterrotating vortices do develop from the rolling up of the vortex sheet shed by a ring wing in a nonaxial flow

Dissert Abstr

**N76-26152\*#** National Aeronautics and Space Administration  
Ames Research Center Moffett Field Calif  
**NONLINEAR EQUATIONS OF MOTION FOR CANTILEVER  
ROTOR BLADES IN HOVER WITH PITCH LINK FLEXIBILITY,  
TWIST, PRECONE, DROOP, SWEEP, TORQUE OFFSET, AND  
BLADE ROOT OFFSET**  
Dewey H Hodges (Army Air Mobility Research and Development  
Lab Moffett Field Calif) May 1976 47 p refs Prepared in  
cooperation with Army Air Mobility Research and Development  
Lab Moffett Field Calif  
(NASA-TM-X-73112 A-6486) Avail NTIS HC \$4 00 CSCL  
01A

Nonlinear equations of motion for a cantilever rotor blade are derived for the hovering flight condition The blade is assumed to have twist precone droop sweep torque offset and blade root offset, and the elastic axis and the axes of center of mass, tension and aerodynamic center coincident at the quarter chord The blade is cantilevered in bending but has a torsional root spring to simulate pitch link flexibility Aerodynamic forces acting on the blade are derived from strip theory based on quasi-steady two-dimensional airfoil theory The equations are hybrid consisting of one integro-differential equation for root torsion and three integro-partial differential equations for flatwise and chordwise bending and elastic torsion The equations are specialized for a uniform blade and reduced to nonlinear ordinary differential equations by Galerkin's method They are linearized for small perturbation motions about the equilibrium operating condition Modal analysis leads to formulation of a standard eigenvalue problem where the elements of the stability matrix depend on the solution of the equilibrium equations Two different forms of the root torsion equation are derived that yield virtually identical numerical results This provides a reasonable check for the accuracy of the equations Author

**N76-26153\*#** National Aeronautics and Space Administration  
Ames Research Center Moffett Field Calif  
**TRANSONIC AERODYNAMIC CHARACTERISTICS OF A  
WING/BODY COMBINATION INCORPORATING JET  
FLAPS**  
John L Holmberg Sep 1975 137 p  
(NASA-TM-X-62461 A-6203) Avail NTIS HC \$6 00 CSCL  
01A

A 0.25-scale semispan wing/body model with two types of jet flaps was tested in the Ames 11- by 11-Foot Transonic Wind Tunnel The objective of that testing was to measure the static aerodynamic forces and moments and wing pressure distributions on six configurations differentiated by wing camber jet flap type and jet flap angle Maximum thrust coefficients were limited to 0.12 Angle of attack was varied from -4 deg to 15 deg for Mach numbers between 0.6 and 0.95 at a constant unit Reynolds number of 18.0 million/m (5.5 million/ft) More refined designs and considerably more testing will be required

to establish the practicability of the total-exhausting jet flap concept  
Author

**N76-26154\*** National Aeronautics and Space Administration  
Lewis Research Center Cleveland Ohio

**AERODYNAMIC PERFORMANCE OF TWO VARIABLE-PITCH FAN STAGES**

Royce D Moore and George Kovich 1976 12 p refs Proposed for Presentation at the 10th Congr of the Intern Council of the Aeronautical Sciences Ottawa 3-8 Oct 1976 sponsored by the Am Inst of Aeronautics and Astronautics  
(NASA-TM-X-73416 E-8658) Avail NTIS HC \$3 50 CSCL 01A

The NASA-Lewis Research Center is investigating a variety of fan stages applicable for short haul aircraft These low-pressure-ratio low-speed fan stages may require variable-pitch rotor blades to provide optimum performance for the varied flight demands and for thrust reversal on landing A number of the aerodynamic and structural compromises relating to the variable-pitch rotor blades are discussed The aerodynamic performance of two variable-pitch fan stages operated at several rotor blade setting angles for both forward and reverse flow application are presented Detailed radial surveys are presented for both forward and reverse flow  
Author

**N76-26155\*** National Aeronautics and Space Administration  
Lewis Research Center Cleveland Ohio

**ACOUSTIC AND AERODYNAMIC EFFECTS OF ROTOR PITCH ANGLES FOR A VARIABLE PITCH, 6 FOOT DIAMETER FAN STAGE Technical Paper**

Richard P Woodward and Frederick W Glaser 1976 20 p refs Presented at the 3rd Aero-Acoustics Conf 20-23 Jul 1976, Palo Alto, Calif Sponsored by AIAA  
(NASA-TM-X-73418 E-8753) Avail NTIS CSCL 01A

An externally driven 12 pressure ratio full-scale fan stage with an adjustable pitch rotor was tested in an outdoor facility at the Lewis Research Center Rotor pitch angles resulting in minimum sideline perceived noise levels are defined as a function of stage thrust Thrust-corrected fan noise variations are examined for operation at constant thrust rotor tip speed and stage work coefficient At constant stage thrust reducing the rotor pitch angle below design values increased the fan noise with the greatest change occurring in the blade passing tone level At constant fan speed the minimum noise occurred at a particular rotor pitch angle which was not the minimum thrust condition With constant stage work coefficient rear quadrant noise increased at above-design speed conditions  
Author

**N76-26156\*** Lockheed Missiles and Space Co Palo Alto Calif  
**INVESTIGATION OF THE SEPARATED FLOW AROUND CONES WITH A TURBULENT BOUNDARY LAYER FOR MACH NUMBERS 8.3 AND 10**

B V Bosheniatov V V Zatoloka and M I Iaroslavl'tsev [1975] 8 p refs Transl into ENGLISH from Izv Sibirsk Otd Akad Nauk SSSR Ser Tekh Nauk no 6 1975 p 43-50  
Avail NTIS HC \$3 50 National Translation Center John Crerar Library Chicago Illinois 60616

The flow around two models in the form of cones to whose rear endfaces a washer forming a ring projection over the conical surface to cause boundary layer separation is attached was investigated in a pulsed hypersonic wind tunnel The models were of steel the roughness of the conical surface was less than 0.004 mm the nose round-off diameter for all the tests was less than 0.05 mm The purpose of the tests was to obtain data about the above-mentioned separation properties of the boundary layer and about whether the properties of the working process in the pulsed tunnel used will influence the test results  
Author

**N76-26161\*** National Aeronautics and Space Administration  
Langley Research Center Langley Station Va

**A VORTEX-LATTICE METHOD FOR THE MEAN CAMBER SHAPES OF TRIMMED NONCOPLANAR PLANFORMS WITH MINIMUM VORTEX DRAG**

John E Lamar Washington Jun 1976 187 p refs  
(NASA-TN-D-8090 L-10522) Avail NTIS HC \$7 50 CSCL 01A

A new subsonic method has been developed by which the mean camber surface can be determined for trimmed noncoplanar planforms with minimum vortex drag This method uses a vortex lattice and overcomes previous difficulties with chord loading specification A Trefftz plane analysis is utilized to determine the optimum span loading for minimum drag then solved for the mean camber surface of the wing which provides the required loading Sensitivity studies comparisons with other theories and applications to configurations which include a tandem wing and a wing winglet combination have been made and are presented  
Author

**N76-26163\*** National Aeronautics and Space Administration  
Langley Research Center Langley Station Va

**A DESIGN APPROACH AND SELECTED WIND TUNNEL RESULTS AT HIGH SUBSONIC SPEEDS FOR WING-TIP MOUNTED WINGLETS**

Richard T Whitcomb Washington Jul 1976 32 p refs  
(NASA-TN-D-8260 L-10908) Avail NTIS HC \$4 00 CSCL 01A

Winglets which are small nearly vertical winglike surfaces substantially reduce drag coefficients at lifting conditions The primary winglet surfaces are rearward above the wing tips secondary surfaces are forward below the wing tips This report presents a discussion of the considerations involved in the design of the winglets measured effects of these surfaces on the aerodynamic forces moments and loads for a representative first generation narrow body jet transport wing and a comparison of these effects with those for a wing tip extension which results in approximately the same increase in bending moment at the wing-fuselage juncture as did the addition of the winglets  
Author

**N76-26164\*** National Aeronautics and Space Administration  
Langley Research Center Langley Station Va

**A HIGH SUBSONIC SPEED WIND TUNNEL INVESTIGATION OF WINGLETS ON A REPRESENTATIVE SECOND-GENERATION JET TRANSPORT WING**

Stuart G Flechner Peter F Jacobs and Richard T Whitcomb Washington Jul 1976 67 p refs  
(NASA-TN-D-8264 L-10387) Avail NTIS HC \$4 50 CSCL 01A

The effects of winglets on the aerodynamic forces and moments loads and crossflow velocities behind the wing tip are discussed The results of the investigation indicate that winglets significantly reduce the drag coefficient at lifting conditions The experiments were conducted in an 8-foot transonic pressure tunnel at Mach numbers from 0.70 to 0.83 and over a lift coefficient range up to 0.65 A semispan model was used  
Author

**N76-26165\*** National Aeronautics and Space Administration  
Langley Research Center Langley Station Va

**REVIEW OF DRAG CLEANUP TESTS IN LANGLEY FULL-SCALE TUNNEL (FROM 1935 TO 1945) APPLICABLE TO CURRENT GENERAL AVIATION AIRPLANES**

Paul L Coe Jr Washington Jun 1976 99 p refs  
(NASA-TN-D-8206 L-10735) Avail NTIS HC \$5 00 CSCL 01A

Results of drag cleanup tests conducted in the Langley full-scale tunnel during the period from 1935 to 1945 are summarized for potential application to current propeller-driven general aviation airplanes Data from tests on 23 airplanes indicate that the drag increments produced by many individual configuration features - such as power plant installation air leakage cockpit canopies control surface gaps and antenna installations - are not large however when the increments are summed the resulting total drag increase is significant On the basis of results of the investigation it appears that considerable reduction in drag can be obtained by proper attention to details in aerodynamic design and by adherence to the guidelines discussed  
Author

**N76-26169#** Optimum Computer Systems Inc Washington D C

**A STUDY OF ATTRITION IN THE DOMESTIC AVIATION FLEET Final Report**

James K Rocks 15 Jul 1975 84 p

(Contract DOT-FA74WAI-496)

(AD-A023271/O FAA-AVP-75-14) Avail NTIS HC\$5 00 CSCL 01/3

About 85 percent of the aircraft (a/c) added to the domestic fleet since 1947 are still registered About 2 percent of the fleet is de-registered every year but this average attrition rate is declining Annual attrition about 0.2 percent among new a/c rises to 2.5 percent among a/c 15 to 20 years old and declines to 1 percent for older a/c 30 percent of which are gone Exports and imports of used a/c accidents irregularities and theft are negligible About 10 percent of the registered fleet is inactive Usage of single-engine a/c shifts from instructional and rental to business and personal as the a/c ages multi-engine use is largely executive business and air taxi Attrition is largely a function of age year-specific type-specific and year-of-manufacture-specific rate differences are minor A projection methodology employing a constructed standard attrition rate is developed and its use described Author

**N76-26172#** South Carolina Aeronautics Commission Columbia **MARKETING AND POLICY STUDY OF COMMUTER AIRLINE SERVICE IN SOUTH CAROLINA Final Report**

Aug 1975 243 p refs Prepared in cooperation with Simat Helliesen and Eichner Inc Newton Center Mass

(PB-249007/6 SCAC-001) Avail NTIS HC \$8 00 CSCL 01B

The opportunities are identified for improving the quality of air service provided in South Carolina through the development of an effective efficient and economically viable system of commuter airline services The socioeconomic trends of the state its history of air transportation and the regulatory environment and operation characteristics of airlines serving light traffic density markets are analyzed In summary it is concluded that a network of commuter air services in a number of South Carolina's short haul markets is feasible and will occur in the future Accordingly the development of commuter airline service in South Carolina should be an important objective of the state GRA

**N76-26185\*#** Kanner (Leo) Associates Redwood City Calif **THE M-15 AIRCRAFT IN THE AIR**

R Nemets Washington NASA Jun 1976 9 p Transl into ENGLISH from Polska (Poland) v 253 no 9 1975 p 4-7

(Contract NASw-2790)

(NASA-TT-F-17066) Avail NTIS HC \$3 50 CSCL 01C

Names, personal impressions and thoughts of some of the participants in the development and building of the M-15 agricultural aircraft are given Illustrations that describe a light jet biplane are included The time sequence of the development is presented Author

**N76-26186\*#** Kanner (Leo) Associates Redwood City Calif **COMPARISON OF WIND TUNNEL TESTS AND FLIGHT TESTS ON AN EXECUTIVE AIRCRAFT**

Washington NASA Jun 1976 23 p Transl into ENGLISH from Assoc Aeronautique Astronautique de France (Paris), no AAAF-NT-75-14 1975 24 p

(Contract NASw-2790)

(NASA-TT-F-17068 AAAF-NT-75-14) Avail NTIS HC \$3 50 CSCL 01C

Wind tunnel tests and flight tests on a business aircraft are compared The direct method involves comparing the unitary curves obtained from the two tests whereas the indirect method consists of establishing from the wind tunnel tests a basic set of adjusted parameters that are converted into the same time based parameters recorded on flight test tapes using flight mechanics equations and a simulation program Results of longitudinal and lateral tests are discussed Author

**N76-26187\*#** Purdue Univ Lafayette Ind

**A UNIQUE FORMULATION OF ELASTIC AIRPLANE LONGITUDINAL EQUATIONS OF MOTION**

Robert L Swaim and Donald G Fullman [1976] 25 p refs (Grant NSG-4003)

(NASA-CR-148205) Avail NTIS HC \$3 50 CSCL 01C

Control-configured vehicle technology has increased the demand for detailed analysis of dynamic stability and control handling and ride qualities and control system dynamics at early stages of preliminary design An approximate but reasonably accurate set of equations of motion are needed for these early analyses Such a formulation is developed for the longitudinal dynamics of elastic airplanes It makes use of only rigid-body aerodynamic stability derivatives in formulating the forces and moments due to elastic motion Verification of accuracy using data for the B-1 airplane shows very good agreement Frequencies and damping ratios of the coupled modes corresponding to complex roots of the characteristic equations agree closely with four symmetric elastic modes included Author

**N76-26188\*#** Purdue Univ Lafayette Ind School of Aeronautics and Astronautics

**LATERAL RIDE QUALITY OF THE B-1 AIRCRAFT SUBJECTED TO A REDUCTION OF LATERAL STATIC STABILITY**

Andrew J Hinsdale 10 Apr 1976 16 p refs Presented at 1976 AIAA Midwest Student Conf Milwaukee 8-10 Apr 1976

(Grant NSG-4003)

(NASA-CR-148206) Avail NTIS HC \$3 50 CSCL 01C

A method to evaluate the lateral ride quality of a B-1 aircraft subjected to a reduction in lateral static stability is developed Ride quality is then found for three different relaxed static stability configurations which are augmented by yaw rate feedback to restore specified handling qualities These cases are compared to the ride quality of the unrelaxed aircraft with the same handling qualities Author

**N76-26189\*#** Purdue Univ Lafayette Ind School of Aeronautics and Astronautics

**RIDE QUALITY SENSITIVITY TO SAS CONTROL LAW AND TO HANDLING QUALITY VARIATIONS**

Philip A Roberts David K Schmidt and Robert L Swaim [1976] 14 p refs

(Grant NSG-4003)

(NASA-CR-148207) Avail NTIS HC \$3 50 CSCL 01C

The RQ trends which large flexible aircraft exhibit under various parameterizations of control laws and handling qualities are discussed A summary of the assumptions and solution technique a control law parameterization review a discussion of ride sensitivity to handling qualities and the RQ effects generated by implementing relaxed static stability configurations are included Author

**N76-26190\*#** National Aeronautics and Space Administration Ames Research Center Moffett Field Calif

**HIGH-ATTITUDE LOW-SPEED STATIC AERODYNAMIC CHARACTERISTICS OF AN F-4D FIGHTER AIRPLANE MODEL WITH LEADING EDGE SLATS**

James C Monfort and W Morrow Whitcomb Aug 1975 158 p refs

(NASA-TM-X-62355 A-5552) Avail NTIS HC \$6 75 CSCL 01C

An investigation was conducted to determine the effects of two-position leading edge slats on the low speed aerodynamic characteristics of a swept wing twin-jet supersonic fighter airplane model at high angle of attack and various Reynolds numbers The investigation was performed at a Mach number of 0.20 over a range of angle of attack from 19 deg to 90 deg and angles of sideslip from -10 deg to 30 deg and Reynolds numbers from 1.97 to 13.12 million per meter Author

**N76-26191\*#** Virginia Polytechnic Inst and State Univ Blacksburg

**STRUCTURAL DYNAMICS, STABILITY, AND CONTROL OF HELICOPTERS Semiannual Technical Progress Report,**

1 Nov 1975 - 31 May 1976

Leonard Meirovitch L Glenn Kraige and Arthur L Hale Jun 1976 97 p refs  
(Grant NSG-1114)  
(NASA-CR-148286 SAPR-3) Avail NTIS HC \$5 00 CSCL 01C

The dynamic synthesis of a helicopter is reported. The method of approach is a variation of the component mode synthesis in the sense that it regards the aircraft as an assemblage of interconnected substructures. The equations of motion are derived in general form by means of the Lagrangian formulation in conjunction with an orderly kinematical procedure that takes into account the superposition of motion of various substructures thus circumventing constraint problems. Author

**N76-26192#** Technion - Israel Inst of Tech Haifa Dept of Aeronautical Engineering

**ANALYSIS OF OPTIMAL EVASIVE MANEUVERS BASED ON A LINEARIZED TWO-DIMENSIONAL KINEMATIC MODEL**

J Shinar and D Steinberg Nov 1975 59 p refs  
(TAE-230) Avail NTIS HC \$4 50

Optimal evasion from proportionally guided missiles is analyzed assuming two-dimensional linearized kinematics. Due to the simplicity of the approach it is possible to include in the mathematical model factors which have been neglected in other analytic studies. It is demonstrated that these factors such as the exact dynamic structure of the guidance system, the location of the saturating element in the guidance loop, the limited roll rate of the evading aircraft, etc., have major effects on the optimal maneuver sequence and determine the order of magnitude of the resulting miss distance. Comparison with studies which used nonlinear kinematic models shows that the domains of validity of linearized kinematics and two-dimensional analysis coincide. In the case of optimal evasion assessment both assumptions are limited in their validity to nearly head-on or tail chase engagements. To analyze engagements of other initial conditions a three-dimensional model is required. The method described can be extended for this type of three-dimensional study. Author

**N76-26193\*#** Grumman Aerospace Corp Bethpage N.Y.  
**VALIDATION OF SCRAMJET EXHAUST SIMULATION TECHNIQUE Final Report**

H B Hopkins W Konopka, and J Leng Washington Jun 1976 85 p refs  
(Contract NAS1-13089)

(NASA-CR-2688 RE-509) Avail NTIS HC \$5 00 CSCL 01C

Scramjet/airframe integration design philosophy for hypersonic aircraft results in configurations having lower aft surfaces that serve as exhaust nozzles. There is a strong coupling between the exhaust plume and the aerodynamics of the vehicle making accurate simulation of the engine exhaust mandatory. The experimental verification of the simulation procedure is described. The detonation tube simulator was used to produce an exact simulation of the scramjet exhaust for a Mach 8 flight condition. The pressure distributions produced by the exact exhaust flow were then duplicated by a cool mixture Argon and Freon 13B1. Such a substitute gas mixture validated by the detonation tube technique could be used in conventional wind tunnel tests. The results presented show the substitute gas simulation technique to be valid for shockless expansions. Author

**N76-26194\*#** National Aeronautics and Space Administration Langley Research Center Langley Station Va  
**COMPARISON OF A LINEAR AND A NONLINEAR WASHOUT FOR MOTION SIMULATORS UTILIZING OBJECTIVE AND SUBJECTIVE DATA FROM CTOL TRANSPORT LANDING APPROACHES**

Russell V Parrish and Dennis J Martin Jr Washington Jun 1976 83 p refs  
(NASA-TN-D-8157 L-10593) Avail NTIS HC \$5 00 CSCL 01C

Objective and subjective data gathered in the processes of comparing a linear and a nonlinear washout for motion simulators reveal that there is no difference in the pilot performance measurements used during instrument landing system (ILS)

approaches with a Boeing 737 conventional takeoff and landing (CTOL) airplane between fixed base linear washout and nonlinear washout operations. However, the subjective opinions of the pilots reveal an important advance in motion cue presentation. The advance is not in the increased cue available over a linear filter for the same amount of motion base travel but rather in the elimination of false rotational rate cues presented by linear filters. Author

**N76-26195\*#** Pratt and Whitney Aircraft East Hartford Conn  
**TWO-STAGE, LOW NOISE ADVANCED TECHNOLOGY FAN VOLUME 2 AERODYNAMIC DATA**

K G Harley and P A Odegard Sep 1975 366 p refs  
(Contract NAS3-16811)

(NASA-CR-134828 PWA-5258-Vol-2) Avail NTIS HC \$10 50 CSCL 21E

Aerodynamic data from static tests of a two-stage advanced technology fan designed to minimize noise are presented. Fan design conditions include delivery of 209 1kg/sec/sq m (42 85 lbm/sec/sq ft) specific corrected flow at an overall pressure ratio of 1.9 and an adiabatic efficiency of 85.3 percent. The 0.836m (2.74ft) diameter first stage rotor has a hub/tip ratio of 0.4 and 365 8m/sec (1200ft/sec) design tip speed. In addition to the moderate tip speed and pressure rise, per stage other noise control design features involve widely spaced blade rows and proper selection of blade-vane ratios. Aerodynamic data are presented for tests with uniform and with hub and tip radially distorted inlet flow. Aerodynamic data are also presented for tests of this fan with acoustic treatments including acoustically treated casing walls, a flowpath exit acoustic ring, and a translating centerbody sonic inlet device. A complete tabulation of the overall performance data, the blade element data, and the power spectral density information relating to turbulence levels generated by the sonic inlet obtained during these tests is included. For vol 1 see N74-33789. Author

**N76-26196\*#** Pratt and Whitney Aircraft East Hartford Conn  
**TWO-STAGE, LOW NOISE ADVANCED TECHNOLOGY FAN VOLUME 3 ACOUSTIC DATA**

T G Sofrin and N Ruloff Jr Sep 1975 316 p refs  
(Contract NAS3-16811)

(NASA-CR-134829 PWA-5303-Vol-3) Avail NTIS HC \$9 75 CSCL 21E

Tabulations and plots of the principal farfield noise characteristics of the fan installed in a special outdoor static noise test facility are presented. Author

**N76-26197\*#** Pratt and Whitney Aircraft East Hartford Conn  
**TWO-STAGE, LOW NOISE ADVANCED TECHNOLOGY FAN 4 AERODYNAMIC FINAL REPORT**

K G Harley and M J Keenan Sep 1975 177 p refs  
(Contract NAS3-16811)

(NASA-CR-134830 PWA-5304) Avail NTIS HC \$7 50 CSCL 21E

A two-stage research fan was tested to provide technology for designing a turbofan engine for an advanced long range commercial transport having a cruise Mach number of 0.85-0.9 and a noise level 20 EPNdB below current requirements. The fan design tip speed was 365 8m/sec (1200ft/sec), the hub/tip ratio was 0.4, the design pressure ratio was 1.9, and the design specific flow was 209.2 kg/sec/sq m (42.85 lbm/sec/sq ft). Two fan-versions were tested: a baseline configuration and an acoustically treated configuration with a sonic inlet device. The baseline version was tested with uniform inlet flow and with tip-radial and hub-radial inlet flow distortions. The baseline fan with uniform inlet flow attained an efficiency of 86.4% at design speed, but the stall margin was low. Tip-radial distortion increased stall margin 4 percentage points at design speed and reduced peak efficiency one percentage point. Hub-radial distortion decreased stall margin 4 percentage points at all speeds and reduced peak efficiency at design speed 8 percentage points. At design speed, the sonic inlet in the cruise position reduced stall margin one percentage point and efficiency 1.5 to 4.5 percentage points. The sonic inlet in the approach position reduced stall margin 2 percentage points. Author

**N76-26198\*# Pratt and Whitney Aircraft East Hartford Conn**  
**TWO-STAGE, LOW NOISE ADVANCED TECHNOLOGY FAN**  
**5 ACOUSTIC FINAL REPORT**

T G Sofrin and N Riloff Jr Sep 1975 115 p refs  
 (Contract NAS3-16811)  
 (NASA-CR-134831 PWA-5305) Avail NTIS HC \$5 50 CSCL  
 21E

The NASA Q2S(quiet two-stage) fan is a 0.836m (32.9 in) diameter model of the STF 433 engine fan selected in a 1972 study for an Advanced Technology Transport (ATT) airplane. Noise-control features include low tip speed, moderate stage pressure rise, large blade-vane spacings, no inlet guide vanes, and optimum blade and vane numbers. Tests were run on the baseline Q2S fan with standard inlet and discharge ducts. Further tests were made of a translating centerbody sonic inlet device and treated discharge ducts. Results were scaled to JT8D and JT3D engine fan size for comparison with current two-stage fans and were also scaled to STF 433 fan size to compare calculated ATT flyover noise with FAR 36 limits. Baseline Q2S results scaled to JT8D and JT3D engine fan sizes showed substantial noise reductions. Calculated unsuppressed baseline ATT flyovers averaged about 2.5 EPNdB below FAR 36 limits. Using measured sonic inlet results scaled baseline Q2S fan results and calculated attenuations for a 1975 technology duct liner projected flyover noise calculations for the ATT averaged about FAR 36 limits minus 10 EPNdB. Advances in suppression technology required to meet the 1985 goal of FAR 36 limits minus 20 EPNdB are discussed. Author

**N76-26199\*# National Aeronautics and Space Administration**  
**Lewis Research Center Cleveland Ohio**

**THE NASA POLLUTION-REDUCTION TECHNOLOGY**  
**PROGRAM FOR SMALL JET AIRCRAFT ENGINES Status**  
**Report**

James S Fear 1976 19 p refs Presented at the 12th Propulsion Conf Palo Alto Calif 26-29 Jul 1976 sponsored by AIAA and Soc of Automotive Engr  
 (NASA-TM-X-73419 E-8757) Avail NTIS HC \$3 50 CSCL  
 21E

Three advanced combustor concepts designed for the AirResearch TFE 731-2 turbofan engine were evaluated in screening tests. Goals for carbon monoxide and unburned hydrocarbons were met or closely approached with two of the concepts with relatively modest departures from conventional combustor design practices. A more advanced premixing/prevaporizing combustor, while appearing to have the potential for meeting the oxides of nitrogen goal as well, will require extensive development to make it a practical combustion system. Smoke numbers for the two combustor concepts were well within the EPA smoke standard. Phase 2 Combustor-Engine Compatibility Testing, which is in its early stages and planned Phase 3 Combustor-Engine Demonstration Testing, are also described. Author

**N76-26201\*# General Electric Co Cincinnati Ohio Aircraft**  
**Engine Group**  
**AN IMPROVED TURBINE DISK DESIGN TO INCREASE**  
**RELIABILITY OF AIRCRAFT JET ENGINES**

W N Barack and P A Domas Jul 1976 142 p refs  
 (Contract NAS3-18564)  
 (NASA-CR-135033 R76AEG324) Avail NTIS HC \$6 00 CSCL  
 21E

An analytical study was performed on a novel disk design to replace the existing high-pressure turbine stage 1 disk on the CF6-50 turbofan engine. Preliminary studies were conducted on seven candidate disk design concepts. An integral multidisk design with bore entry of the turbine blade cooling air was selected as the improved disk design. This disk has the unique feature of being redundant such that if one portion of the disk would fail, the remaining portion would prevent the release of large disk fragments from the turbine system. Low cycle fatigue lives, initial defect propagation lives, burst speed, and the kinetic energies of probable disk fragment configurations were calculated, and comparisons were made with the existing disk both in its current material IN 718 and with the substitution of an advanced alloy Rene 95. The design for redundancy approach which necessitated the addition of approximately 44.5 kg (98 lb)

to the design disk substantially improved the life of the disk. The life to crack initiation was increased from 30,000 cycles to more than 100,000 cycles. The cycles to failure from initial defect propagation were increased from 380 cycles to 1564 cycles. Burst speed was increased from 126 percent overspeed to 149 percent overspeed. Additionally, the maximum fragment energies associated with a failure were decreased by an order of magnitude. Author

**N76-26202\*# Boeing Commercial Airplane Co Seattle Wash**  
**FLIGHT EFFECTS ON NOISE GENERATED BY THE JT8D-17**  
**ENGINE IN A QUIET NACELLE AND A CONVENTIONAL**  
**NACELLE AS MEASURED IN THE NASA-AMES 40- BY**  
**80-FOOT WIND TUNNEL**

Frank G Strout Washington Jun 1976 101 p refs  
 (Contract NAS2-8213)  
 (NASA-CR-2576 D6-42813-1) Avail NTIS HC \$5 50 CSCL  
 21E

A JT8D-17 turbofan engine was tested in the NASA-Ames 40- by 80-foot wind tunnel to determine flight effects on jet and fan noise. Baseline, quiet nacelle with 20-lobe ejector/suppressor and internal mixer configurations were tested over a range of engine power settings and tunnel velocities. Flight effects derived from the 40- by 80-foot wind tunnel test are compared with 727/JT8D flight test data and with model data obtained in a smaller wind tunnel. Procedures are defined for measuring noise data in a wind tunnel relatively near the sources and analyzing the results to obtain far-field flight effects. Wind tunnel and 727 flight test noise results compare favorably for both the baseline and quiet nacelle configurations. Two reports are provided including a comprehensive version with extensive test results and analysis and the subject summary version that emphasizes data analysis and program finding. Author

**N76-26203\*# National Aeronautics and Space Administration**  
**Langley Research Center Langley Station Va**  
**ANALYSIS OF EXPERIMENTAL RESULTS OF THE INLET**  
**FOR THE NASA HYPERSONIC RESEARCH ENGINE**  
**AEROTHERMODYNAMIC INTEGRATION MODEL**

Earl H Andrews, Jr and Ernest A Mackley Washington Jun 1976 50 p refs  
 (NASA-TM-X-3365 L-10400) Avail NTIS HC \$4 00 CSCL  
 21E

An aerodynamic engine inlet analysis was performed on the experimental results obtained at nominal Mach numbers of 5.6 and 7 from the NASA Hypersonic Research Engine (HRE) Aerothermodynamic Integration Model (AIM). Incorporation on the AIM of the mixed-compression inlet design represented the final phase of an inlet development program of the HRE Project. The purpose of this analysis was to compare the AIM inlet experimental results with theoretical results. Experimental performance was based on measured surface pressures used in a one-dimensional force-momentum theorem. Results of the analysis indicate that surface static-pressure measurements agree reasonably well with theoretical predictions except in the regions where the theory predicts large pressure discontinuities. Experimental and theoretical results both based on the one-dimensional force-momentum theorem yielded inlet performance parameters as functions of Mach number that exhibited reasonable agreement. Previous predictions of inlet unstart that resulted from pressure disturbances created by fuel injection and combustion appeared to be pessimistic. Author

**N76-26207# Sikorsky Aircraft, Stratford Conn Sikorsky Aircraft**  
**Div**

**ROTOR BROADBAND NOISE RESULTING FROM TIP**  
**VORTEX/BLADE INTERACTION Final Report, Jun 1972 -**  
**Dec 1974**

Charles L Munch Robert W Patterson and Henry Day Feb 1975 97 p refs  
 (Contract DAHC04-72-C-0040)  
 (AD-A020692 SER-50909) Avail NTIS CSCL 01/3

The study described was conducted to investigate tip vortex/blade interaction as a source of broadband noise to

hovering helicopter rotors. Observations of full scale, multi-blade rotors indicate that at moderate to high lift conditions the tip vortex, passing beneath a blade caused a stall pocket to form near the blade tip. At these same lift conditions rotor noise (expressed as Perceived Noise Level) was observed to increase at a faster rate than for lower lift conditions. This behavior has been termed 'noise divergence'. An experimental investigation was conducted in the UARL Acoustic Research Wind Tunnel to define the noise characteristics associated with this tip vortex/blade interaction. GRA

**N76-26209** Motoren- und Turbinen-Union Muenchen G m b H (West Germany)

**AIRCRAFT GAS TURBINE CYCLE PROGRAMS REQUIREMENTS FOR COMPRESSOR AND TURBINE PERFORMANCE PREDICTION**

K Bauerfeind /In AGARD Mod Prediction Methods for Turbomachine Performance Jun 1976 12 p

Typical design applications for an engine performance program are shown. A characteristic structure is presented of a thermodynamic engine model for steady state performance prediction. A technique for determining nondimensional engine performance is derived from non-dimensional component performance. Compressor and turbine characteristics are also discussed. A S K

**N76-26210** Iowa State Univ of Science and Technology, Ames **COMPRESSOR AND TURBINE PERFORMANCE PREDICTION SYSTEM DEVELOPMENT LESSONS FROM THIRTY YEARS OF HISTORY**

George K Serovy /In AGARD Mod Prediction Methods for Turbomachine Performance Jun 1976 19 p refs

Methods are reviewed for prediction of aerodynamic performance of aircraft propulsion system turbomachinery configurations. Progress is traced in the two classes of methods which can predict only overall performance characteristics or maps. These methods were conceived at least thirty years ago and are not only used, but continue to be the subject of research today. Prediction methods which include flow field definition in the blade passages of compressors and turbines are described.

Author

**N76-26211** Rolls-Royce Ltd Derby (England) Compressor Research Dept

**AXIAL FLOW COMPRESSOR PERFORMANCE PREDICTION**

R A Wall /In AGARD Mod Prediction Methods for Turbomachine Performance Jun 1976 34 p

Owing to the nature of axial flow compressors, performance prediction is characteristically difficult to achieve by theoretical analysis and therefore recourse to gross empiricism faced with theory is fundamental to methods employed. Factors determining the performance requirements of compressors and the physical mechanisms which control their ability to satisfy these requirements are discussed to expose the nature of compressors. Compressor design optimization is described to illustrate how effective compromise can be achieved between design point performance and various off-design excursions demanded by turbomachine performance. Typical performance prediction methods which reflect the nature of compressors and quantify their performance characteristics are described with some reference to the influence of engine environmental factors. Potential developments are discussed which could influence the type of design employed in future engines. Author

**N76-26212** Dynatech R/D Co. Cambridge Mass Engineering Mechanics Dept

**FLOW FIELD AND PERFORMANCE MAP COMPUTATION FOR AXIAL-FLOW COMPRESSORS AND TURBINES**

Richard A Novak /In AGARD Mod Prediction Methods for Turbomachine Performance Jun 1976 27 p refs

The current research emphasis on two-dimensional computing

schemes, and upon the compressor rather than on the turbine is not the result of bias. Currently rapid progress is being made on the implementation of quasi-three-dimensional techniques. Computing techniques whose objective is to define the detailed flow field within a blade row are described. The problems associated with axisymmetric performance computation for the axial turbine are also discussed. The discussion and development of the system is in the context of axial compressors. Author

**N76-26213** Creare, Inc Hanover NH Fluids/Thermal Engineering Div

**DESIGN OPTIMIZATION AND PERFORMANCE MAP PREDICTION FOR CENTRIFUGAL COMPRESSORS AND RADIAL INFLOW TURBINES**

David Japikse /In AGARD Mod Prediction Methods for Turbomachine Performance Jun 1976 15 p refs

The initial specification of compressor and turbine geometry and performance characteristics including operating maps can follow different paths depending on the degree of departure from previous design experience. Principal attention is focused on totally new design problems requiring systematic design optimization to meet performance criteria under diverse operating conditions. The fundamental flow physics involved for both the centrifugal compressor and radial inflow turbine are briefly reviewed with principal attention focused on the strategy used for selecting optimum stage configurations. The performance map is obtained from the final step of this design optimization exercise. Author

**N76-26214** Societe Nationale d Etudes et de Construction de Moteurs d Aviation Moissy-Cramayel (France) Dept Thermodynamique et Performances Direction Technique

**CHARACTERIZATION OF COMPONENTS PERFORMANCE AND OPTIMIZATION OF MATCHING IN JET-ENGINE DEVELOPMENT**

Alain G Habrard /In AGARD Mod Prediction Methods for Turbomachine Performance Jun 1976 19 p refs

Design and development of jet-engines require prediction and later characterization through test analysis of the performance of the engine and its components. Knowledge of component characteristics is generally synthesized in mathematical models which contribute highly to efficient design and development. At the beginning of development (i.e. before first runs of prototype engines) models are essentially based on estimates and rig test results. Problems are then encountered when engine test results are compared to prediction. Methods using engine test analysis to identify component operating characteristics as installed in the engine and leading to models more representative of aerothermodynamic behavior of engines are presented. Such models appear to be very useful tools during the various phases of development. Application and coordination with tests are discussed and particularly relative matching of components and control schedules optimization. Author

**N76-26215** Defence Scientific Information Service Ottawa (Ontario)

**BIBLIOGRAPHY ON MODERN PREDICTION METHODS FOR TURBOMACHINE PERFORMANCE**

A S Reeves /In AGARD Mod Prediction Methods for Turbomachine Performance Jun 1976 31 p

A bibliography is presented on numerical techniques for predicting the performance of turbomachines. Topics include boundary layer methods, axial flow compressor, turbine blades, damping factors and modern engine design concepts. A S K

**N76-26218\*** National Aeronautics and Space Administration Langley Research Center Langley Station Va

**WIND-TUNNEL INVESTIGATION OF A FOWLER FLAP AND SPOILER FOR AN ADVANCED GENERAL AVIATION WING**

John W Paulson Jr Washington Jun 1976 80 p refs (NASA-TN-D-8236 L-10736) Avail NTIS HC \$5.00 CSCL 01C

The wing was tested without fuselage or empennage and was fitted with approximately three-quarter span Fowler flaps and half span spoilers. The spoilers were hinged at the 70 percent chord point and vented when the flaps were deflected. Static longitudinal and lateral aerodynamic data were obtained over an angle of attack range of -8 deg to 22 deg for various flap deflections and positions, spoiler geometries, and vent lip geometries. Lateral characteristics indicate that the spoilers are generally adequate for lateral control. In general, the spoiler effectiveness increases with increasing angle of attack, increases with increasing flap deflections, and is influenced by vent lip geometry. In addition, the data show that some two-dimensional effects on spoiler effectiveness are reduced in the three-dimensional case. Results also indicate significant increase in lift coefficient as the Fowler flaps are deflected when the flap was fully deflected, the maximum wing lift coefficient was increased about 96 percent. Author

**N76-26221\*** Wichita State Univ, Kans, Dept of Aeronautical Engineering

**DEVELOPMENT OF CAPABILITIES FOR STALL/SPIN RESEARCH** Final Report, 1 Jun 1975 - 20 Jun 1976

Andrew Craig 20 Jun 1976 42 p

(Grant NsG-1189)

(NASA-CR-148287) Avail NTIS HC \$4.00 CSCL 14B

Apparatus and techniques were developed for measuring in a low-speed wind tunnel the static and dynamic (rotary balance) aerodynamic data pertinent to spin behavior of a general aviation aircraft. The main results were (1) collection of static force and moment data for several airplane configurations at angles of attack from 0 to 90 degrees and angles of sideslip from 0 to 40 degrees, and (2) difficulties, shortcomings, and unsuitability of some aspects of the rotary balance mount as constructed were discovered and identified for avoidance in a new design for a mount. Author

**N76-26225\*** National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif

**AN EXPERIMENTAL INVESTIGATION OF END TREATMENTS FOR NONRETURN WIND TUNNELS**

William T Eckert, Kenneth W Mort, and J E Piazza, Washington Jun 1976 56 p refs. Sponsored jointly with Army Air Mobility R and D Lab, Moffett Field, Calif

(NASA-TM-X-3402, A-6206) Avail NTIS HC \$4.50 CSCL 14B

The results of a series of flow quality and performance tests on several inlet and exit configurations for nonreturn wind tunnels are presented. Test section flow angularities, local dynamic pressure variations, and total-pressure-loss variations are presented as functions of wind-to-test-section dynamic pressure ratio. The results show that a nonreturn wind tunnel should have end treatments with three characteristics: (1) a vertical exit system, (2) a horizontal inlet system, and (3) an area of protected enclosure at the inlet. Inlet and exhaust treatments were developed that produced good aerodynamic flow qualities with low power penalties. Author

**N76-26291\*** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany), Abteilung Kunststoffe

**THEORETICAL AND EXPERIMENTAL INVESTIGATIONS ON FIBER REINFORCED PLASTIC LANDING GEAR SPRING BLADES FOR LIGHT AIRCRAFT**

Rainer Schuetze 12 Jan 1976 37 p refs. In GERMAN. ENGLISH summary. Report will also be announced as translation.

(DLR-FB-76-06) Avail NTIS HC \$4.00 DFVLR, Cologne DM 16.20

The development of several landing gear spring blades for lightweight aircraft is discussed. A special sandwich structure provided high longitudinal stresses in the faces and high shear stresses in the sandwich core. The length of the spring blades

made a high bending stiffness necessary, therefore apart from glass fibers reinforcements with higher Young-modulus, as carbon- and Kevlar-49-fibers were also provided for tensile sandwich faces. All blades were statically and dynamically tested on a gravitational fall test-bed. Using Kevlar-49-fibers in the tensile sandwich face, the structural weight could be further reduced and damping conditions improved compared with the GRP-sandwich blade. Author (ESA)

**N76-26329\*** Air Force Materials Lab, Wright-Patterson AFB, Ohio

**PROCEEDINGS OF THE TRISERVICE CORROSION OF MILITARY EQUIPMENT CONFERENCE, VOLUME 12, SESSIONS 1-3, Final Report, 31 Oct 1974 - 1 Feb 1975**

Fred H Meyer Jr, Sep 1975 549 p refs. Conf held at Dayton, Ohio 29-31 Oct 1974

(AF Proj 7381)

(AD-A021053, AFML-TR-75-42-Vol-1) Avail NTIS CSCL 11/6

Papers are presented on corrosion of aircraft, rocket, and spacecraft components, metals in military equipment, composite materials, chemical attack, stress corrosion, and fuel composition. GRA

**N76-26336\*** General Dynamics/Fort Worth, Tex

**DEVELOPMENT OF A WELDABLE HIGH STRENGTH STEEL** Final Report, Mar 1973 - Feb 1975

C D Little and P M Machmeir, Wright-Patterson AFB, Ohio AFML Sep 1975 137 p refs

(Contract F33615-73-C-5093, AF Proj 7351)

(AD-A021174, AFML-TR-75-148) Avail NTIS CSCL 11/6

An existing 10Ni-8Co-2Cr-1Mo steel (HY180) was modified to a higher strength level to meet the need for weldable and fracture-resistant high-strength steel alloys required in current and future airframe structural applications. This steel, which relies on the precipitation of a secondary hardening precipitate in a highly dislocated lath martensite matrix at an elevated aging temperature, appeared to be an excellent candidate for modification to meet high toughness requirements at high strength levels (230-250 Ksi UTS). Eight experimental alloys were melted where the level of alloy addition was controlled by factorial and regression analysis techniques. Six of the eight experimental alloys met the mechanical property requirements. The selected alloy composition (14Co-10Ni-2Cr-1Mo-0.16C) was scaled-up to a 2000 lb VIM/VAR heat with no apparent decrease in mechanical properties. Preliminary results indicate low fatigue crack growth rates both in ambient and corrosive environments, improved S/N fatigue, and good general corrosion resistance. The 14Co-10Ni-2Cr-1Mo-0.16C steel (AF1410) was found to be quite weldable by conventional arc weld processes. GRA

**N76-26350\*** Boeing Aerospace Co, Seattle, Wash

**CERAMIC AIRFRAME BEARINGS** Final Report, Jan 1974 - Nov 1975

Jan W VanWyk 1 Nov 1975 95 p refs

(Contract N00019-74-C-0264)

(AD-A020170, D180-19181-1) Avail NTIS CSCL 11/8

A friction and wear screening program was conducted using silicon nitride rider specimens in contact with various ceramic coatings on titanium. A lubricant reservoir bearing surface developed under a previous contract for a solid ceramic surface was evaluated in this program. Three plain spherical bearing designs were fabricated utilizing a 1 3/8 inch diameter silicon nitride ball. The bearing outer race lubricant reservoirs contained an MoS2 solid lubricant compact and a polyolefin expansion material. Two of the bearing designs were tested under conditions simulating use in a helicopter pitch link bearing application. Tests conducted at Sikorsky resulted in bearing failure after 3 and 6.5 hours of operation. Tests at Vertol resulted in one bearing ball fracture after 1006 hours of test time. The bearing surfaces on the two other Vertol test bearings were in good operating condition after the 1006 hour test. It was concluded that the

ceramic airframe bearing shows promise for future application but that additional development was required Author (GRA)

**N76-26352#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt Lampoldshausen (West Germany) Inst fuer Chemische Raketenantriebe

**PROPELLANT SELECTION FOR RAMJETS WITH SOLID FUEL**

Robert H Schmucker and Hendrik Lips 11 Mar 1976 33 p refs In GERMAN, ENGLISH summary Report will also be announced as translation (DLR-FB-76-18) Avail NTIS HC \$4 00 DFVLR Cologne DM 14 20

Ramjet propulsion using solid propellant for post-boost acceleration of missiles exhibits several favorable properties brought about by heterogeneous combustion A simplified theory for calculating the performance of possible propellants classified with respect to maximum fuel-specific impulse is presented The optimal choice of fuel from a system standpoint, must consider volume constraints and defines the requirements for motor geometry Author (ESA)

**N76-26438#** Naval Ship Research and Development Center Bethesda, Md Aviation and Surface Effects Dept

**EXPERIMENTAL INVESTIGATION OF THE HIGH VELOCITY COANDA WALL JET APPLIED TO BLUFF TRAILING EDGE CIRCULATION CONTROL AIRFOILS** Research and Development Report, Sep 1971 - Apr 1973

Robert J Englar Sep 1975 117 p refs Supersedes TN-AL-308 (AD-A019417 Aero-1213 TN-AL-308) Avail NTIS CSCL 20/4

A two-dimensional experimental investigation intended to probe the mechanism for reduction in performance of circulation control elliptic airfoils in compressible flow was conducted subsonically on a 20-percent-thick modified elliptic profile employing high Coanda wall jet velocities The results include detailed pressure distributions (both normal and chordwise) and trailing edge shear stress measurements made with a hot film anemometer for a range of jet slot heights and jet total pressures corresponding to high subsonic, sonic, and supersonic jet velocities Jet Mach numbers of almost 1.3 were found to have no adverse effects on the airfoil performance, and the degrading jet detachment phenomenon was never encountered Significant differences in the jet flow field with and without an external free stream were noted, as was the deviation of the static pressure across the jet from a constant value as assumed in conventional boundary layer analysis Airfoil lift performance was found to vary with slot height and the detailed shear stress measurement enabled location of the jet separation point Also discussed is the calibration and use of the hot film shear stress probe Author (GRA)

**N76-26496** British Library Lending Div Boston Spa (England) **TURBO-COMPRESSORS**

H Schubert [1975] 29 p refs Transl into ENGLISH from Ver Deut Ing Z (Dusseldorf) v 117 no 15/16 1975 p 752-768 (BLL-NEL-TT-2654-(6075 461)) Avail British Library Lending Div Boston Spa, Engl

A literature survey on turbo-compressors covering work completed in 1973-1974 was presented Research was primarily concentrated on the improvement of prediction methods for compressor characteristics and hence on the improvement of the knowledge of the flow processes in the individual compressor stages Since an accurate calculation of the flow in the form of a general solution is not yet possible the aggregate problem of the three-dimensional frictional flow of a compressible medium within the compressor is treated by splitting it up into mutually matched partial problems A total of 560 references were quoted YJA

**N76-26507** National Aeronautical Establishment Ottawa (Ontario) Unsteady Aerodynamics Lab

**RECENT ADVANCES IN TECHNIQUES FOR DYNAMIC STABILITY TESTING AT NAE**

Orlik-Rueckemann In Natl Res Council of Canada Quart Bull of the Div of Mech Eng and the Natl Aeron Estab 31 Mar 1976 p 1-22 refs Presented at Symp on Unsteady Aerodyn Ariz Univ, Tucson Mar 1975

Several new experimental techniques developed over the past few years include dynamic half model experiments at moderate angles of attack dynamic interference experiments with two oscillating models oscillatory experiments on models with simulated exhaust plume, dynamic cross coupling experiments and vertical acceleration experiments In each case a brief description is given accompanied by a discussion of the rationale behind the development of the technique and an indication of its potential applications Author

**N76-26508** Division of Mechanical Engineering Ottawa (Ontario) Fuels and Lubricants Lab

**JET FUEL HANDLING AND SAFETY**

L Gardner In Natl Res Council of Canada Quart Bull of the Div of Mech Eng and the Natl Aeron Estab 31 Mar 1976 p 23-35 refs

In Canada two types of jet fuel predominate both of which are required because of climatic conditions While the wide cut fuel can from theoretical considerations be considered a more flammable fuel, under practical conditions the hazards associated with each are quite similar and stringent safety precautions have to be applied with both fuels Recognizing the hazards of electrostatic charging Canada has adopted the use of a static dissipator additive to control the problem In addition to fire safety fuel handling requires careful attention to avoid contamination of fuel which is another safety measure Quality control of the fuels from refinery to the aircraft and the removal of solid contaminants and water is essential to obtain safe aircraft operation Author

**N76-26510\*** National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

**MICROECONOMIC ANALYSIS OF MILITARY AIRCRAFT BEARING RESTORATION**

Gerald F Hein 1976 20 p refs Presented at Bearing Restoration by Grinding Seminar St Louis, 20-21 May 1976 sponsored by Army Aviation Systems Command and NASA Lewis (NASA-TM-X-73439, E-8728) Avail NTIS HC \$3 50 CSCL 131

The risk and cost of a bearing restoration by grinding program was analyzed A microeconomic impact analysis was performed The annual cost savings to US Army aviation is approximately \$950 000 00 for three engines and three transmissions The capital value over an indefinite life is approximately ten million dollars The annual cost savings for US Air Force engines are approximately \$313 000 00 with a capital value of approximately 3.1 million dollars Author

**N76-26512\*** National Aeronautics and Space Administration Lewis Research Center, Cleveland Ohio

**EVALUATION OF BALL AND ROLLER BEARINGS RESTORED BY GRINDING**

R J Parker E V Zaretsky and S M Chen (Army Aviations Systems Command St Louis) 1976 35 p refs Presented at Bearing Restoration by Grinding Seminar St Louis 20-21 May 1976 sponsored by Army Aviation Systems Command and NASA Lewis (NASA-TM-X-73440 E-8728b) Avail NTIS HC \$4 00 CSCL 131

The restoration by grinding of those rolling element bearings which are currently being discarded at aircraft engine and transmission overhaul is considered Three bearing types were selected from the UH-1 helicopter engine and transmission for the pilot program Groups of each of these bearings were visually



and dimensionally inspected for suitability for restoration. A total of 250 bearings were restored by grinding. Of this number 30 bearings from each type were endurance tested to a TBO of 1600 hours. No bearing failures occurred related to the restoration by grinding process. The two bearing failures which occurred were due to defective rolling elements and were typical of those which may occur in new bearings. The restorable component yield to the three groups was in excess of 90 percent. Author

**N76-26514\*#** Pratt and Whitney Aircraft, East Hartford, Conn. **EXPERIMENTAL STUDY OF TRANSIENT DYNAMICS OF A FLEXIBLE ROTOR. Final Report**  
D. H. Hibner and D. F. Buono. Washington, Jun 1976. 45 p. (Contract NAS3-18523)  
(NASA-CR-2703, PWA-5333) Avail NTIS HC \$4.00 CSDL 21E

The results of an experimental program to investigate the transient response of a flexible rotor are presented. The program consisted of a series of tests conducted on a rig with a rotor designed to operate above its first bending critical speed. The purpose of the tests was to obtain experimental data on the transient behavior of a flexible rotor under conditions simulating those which might occur in a jet aircraft engine. The scope of the program included tests to measure the response of both balanced and unbalanced rotors during steady-state operation, acceleration, deceleration, and simulated blade loss. Author

**N76-26566** Kobe Univ. (Japan). **VIBRATION OF ROTORS THROUGH CRITICAL SPEEDS**  
Takuzo Iwatsuba. In Shock and Vibration Inform. Center. The Shock and Vibration Digest, Vol. 8, No. 2, Feb 1976. p. 89-98. refs.  
CSDL 20/11

The behavior of the rotor during acceleration and deceleration through critical speeds and to the maximum amplitude and stress of the shaft are examined. Author

**N76-26585\*#** National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va. **APPLICATION OF THE AERODYNAMIC ENERGY CONCEPT TO FLUTTER SUPPRESSION AND GUST ALLEVIATION BY USE OF ACTIVE CONTROLS**  
E. Nissim (Technion-Israel Inst. of Technol.), A. Caspi (Israel Aircraft Ind.) and I. Lottati (Technion-Israel Inst. of Technol.). Washington, Jun 1976. 93 p. refs.  
(NASA-TN-D-8212, L-10738) Avail NTIS HC \$5.00 CSDL 01A

The effects of active controls on flutter suppression and gust alleviation of the Arava twin turboprop STOL transport and the Westwind twinjet business transport are investigated. The active control surfaces are introduced in pairs which include in any chosen wing strip a 20-percent chord leading-edge control and a 20-percent chord trailing-edge control. Each control surface is driven by a combined linear-rotational sensor system located on the activated strip. The control law is based on the concept of aerodynamic energy and utilizes previously optimized control law parameters based on two-dimensional aerodynamic theory. The best locations of the activated system along the span of the wing are determined for bending-moment alleviation, reduction in fuselage accelerations, and flutter suppression. The effectiveness of the activated system over a wide range of maximum control deflections is also determined. Two control laws are investigated. The first control law utilizes both rigid-body and elastic contributions of the motion. The second control law employs primarily the elastic contribution of the wing and leads to large increases in the activated control effectiveness as compared with the basic control law. The results indicate that flutter speed can be significantly increased (over 70 percent increase) and that the bending moment due to gust loading can be almost totally eliminated by a control system of about 10 to 20 percent span with reasonable control-surface rotations. Author

**N76-26949\*#** National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va. **CONCORDE NOISE-INDUCED BUILDING VIBRATIONS FOR SULLY PLANTATION, CHANTILLY, VIRGINIA**  
W. H. Mayes, H. F. Scholl, D. G. Stephens, B. G. Holliday, R. DeLoach, H. K. Holmes, R. B. Lewis, and J. W. Lynch. Washington, Jun 1976. 43 p. refs.  
(NASA-TM-X-73919, Rept-2630) Avail NTIS HC \$4.00 CSDL 20A

A study to assess the noise-induced building vibrations associated with Concorde operations is presented. The approach is to record the levels of induced vibrations and associated indoor/outdoor noise levels in selected homes, historic and other buildings near Dulles and Kennedy International Airports. Presented is a small, representative sample of data recorded at Sully Plantation, Chantilly, Virginia during the period of May 20 through May 28, 1976. Recorded data provide relationships between the vibration levels of walls, floors, windows, and the noise associated with Concorde operations (2 landings and 3 takeoffs), other aircraft, nonaircraft sources, and normal household activities. Results suggest that building vibrations resulting from aircraft operations were proportional to the overall sound pressure levels and relatively insensitive to spectral differences associated with the different types of aircraft. Furthermore, the maximum levels of vibratory response resulting from Concorde operations were higher than those associated with conventional aircraft. The vibrations of nonaircraft events were observed in some cases to exceed the levels resulting from aircraft operations. These nonaircraft events are currently being analyzed in greater detail. Author

**N76-26950\*#** National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va. **NOISE MEASUREMENTS FOR A TWIN-ENGINE COMMERCIAL JET AIRCRAFT DURING 3 DEG APPROACHES AND LEVEL FLYOVERS**  
Earl C. Hastings, Jr., Robert E. Shanks, and Arnold W. Mueller. Washington, Jul 1976. 60 p. refs.  
(NASA-TM-X-3387, L-10780) Avail NTIS HC \$4.50 CSDL 20A

Noise measurements have been made with a twin-engine commercial jet aircraft making 3 deg approaches and level flyovers. The flight-test data showed that, in the standard 3 deg approach configuration with 40 deg flaps, effective perceived noise level (EPNL) had a value of 109.5 effective perceived noise decibels (EPNdB). This result was in agreement with unpublished data obtained with the same type of aircraft during noise certification tests. The 3 deg approaches made with 30 deg flaps and slightly reduced thrust reduced the EPNL value by 1 EPNdB. Extended center-line noise determined during the 3 deg approaches with 40 deg flaps showed that the maximum reference A-weighted sound pressure level (LA,max)ref varied from 100.0 A-weighted decibels 2.01 km (1.08 n mi) from the threshold to 87.4 db(A) at 6.12 km (3.30 n mi) from the threshold. These test values were about 3 db(A) higher than estimates used for comparison. The test data along the extended center line during approaches with 30 deg flaps were 1 db(A) lower than those for approaches with 40 deg flaps. Flight-test data correlating (LA,max)ref with thrust at altitudes of 122 m (400 ft) and 610 m (2000 ft) were in agreement with reference data used for comparison. Author

**N76-27103\*#** National Materials Advisory Board, Washington, D. C. **AEROSPACE COST SAVINGS IMPLICATIONS FOR NASA AND THE INDUSTRY. Final Report**  
1975. 132 p. refs.  
(Contract NASw-2371)  
(NASA-CR-148224, PB-249463/1, NMAB-326) Avail NTIS HC \$6.00 CSDL 15E

Factors that have a major influence on cost in airframe, engine, and helicopter procurement and operation are identified. Current cost-reduction efforts are reviewed, and technical programs that offer potential for lowering costs are proposed for possible implementation by NASA. In view of the growing impact of increasing fuel costs on the life cycle cost of aircraft vehicles,

major attention is given to operating and maintenance costs as well as to manufacturing costs. Seven general conclusions are reached, recommendations made, and thirty-two specific programs are proposed. GRA

**N76-27129#** Executive Office of the President, Washington D C

**AERONAUTICS AND SPACE REPORT OF THE PRESIDENT, 1975 ACTIVITIES**

Gerald R Ford 1975 116 p

Avail NTIS MF \$2.25 SOD HC \$1.85

Achievements in aeronautics and space in 1975 are summarized. Scientific investigations which have advanced understanding of the universe, the solar system, and the earth's space environment, atmosphere and surface features are included along with the increased reliability and diversity of operational satellite systems for weather data and communications. The Apollo Soyuz Test Project progress on the space shuttle and aeronautical research into quieter, more economical, and safer aircraft are among the topics discussed. Author

**N76-27164\*#** Houston Univ Tex

**CARGO TRANSPORTATION BY AIRSHIPS A SYSTEMS STUDY Final Report**

C J Huang and Charles Dalton Washington NASA May 1976 196 p refs

(NASA-CR-2636, S-452 JSC-10655) Avail NTIS HC \$7.50 CSCL 01C

A systems engineering study of a lighter than air airship transportation system was conducted. The feasibility of the use of airships in hauling cargo was demonstrated. Social, legal, environmental and political factors were considered as well as the technical factors necessary to design an effective airship transportation system. In order to accomplish an effective airship transportation program, two phases of implementation were recommended. Phase I would involve a fleet of rigid airships of 3.5 million cubic feet displacement capable of carrying 25 tons of cargo internal to the helium-filled gas bag. The Phase I fleet would demonstrate the economic and technical feasibility of modern-day airships while providing a training capability for the construction and operation of larger airships. The Phase II portion would be a fleet of rigid airships of 12 million cubic feet displacement capable of carrying a cargo of 100 tons a distance of 2,000 miles at a cruising speed of 60 mph. An economic analysis is given for a variety of missions for both Phase I and Phase II airships. Author

**N76-27166\*#** National Aeronautics and Space Administration Ames Research Center Moffett Field Calif

**INVESTIGATION OF TWO BIFURCATED-DUCT INLET SYSTEMS FROM MACH 0 TO 2.0 OVER A WIDE RANGE OF ANGLES OF ATTACK**

Eldon A Latham May 1976 81 p refs

(NASA-TM-X-73118 A-6512) Avail NTIS HC \$5.00 CSCL 01A

A 15.354 percent/scale lightweight fighter type inlet/forebody was tested over a Mach number range of 0 to 2.0. Model configurations consisted of side-mounted normal shock and fixed overhead ramp type inlets. Each configuration consisted of two inlets ducted (bifurcated) to supply a single engine face. The normal shock inlet variables included a boundary layer splitter bleed system, alternate boundary layer splitter plates, alternate upper and lower cowl lip shapes, and a blow-in-door (auxiliary inlet) in one lower lip. The only variable of the fixed overhead ramp inlet was the boundary layer bleed flow. Reynolds numbers ranged from  $7.6 \times 10^6$  to  $19.5 \times 10^6$  m. Angle of attack ranged from 10 to 35 deg and angle of sideslip from 1 to 8 deg. Test measurements included engine face total pressure, recovery, steady-state distortion, dynamic distortion, and surface static pressures on the forebody and inlet surfaces. Author

**N76-27167\*#** National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

**NOZZLE AND WING GEOMETRY EFFECTS ON OTW AERODYNAMIC CHARACTERISTICS**

U VonGlahn and D Groesbeck 1976 28 p refs. Presented at the 12th Propulsion Conf, Palo Alto Calif, 26-29 Jul 1976, sponsored by AIAA and SAE. (NASA-TM-X-73420 E-8758) Avail NTIS HC \$4.00 CSCL 01A

The effects of nozzle geometry and wing size on the aerodynamic performance of several 5:1 aspect ratio slot nozzles are presented for over-the-wing (OTW) configurations. Nozzle geometry variables include roof angle, sidewall cutback, and nozzle chordwise location. Wing variables include chord size and flap deflection. Several external deflectors also were included for comparison. The data indicate that good flow turning may not necessarily provide the best aerodynamic performance. The results suggest that a variable exhaust nozzle geometry offers the best solution for a viable OTW configuration. Author

**N76-27168\*#** National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

**AERODYNAMIC AND ACOUSTIC PERFORMANCE OF A CONTRACTING COWL HIGH THROAT MACH NUMBER INLET INSTALLED ON NASA QUIET ENGINE C**

Harry E Blommer and John W Schaefer 1976 20 p refs. Presented at the 3d Aero-Acoustic Conf, Palo Alto Calif, 20-23 Jul 1976, sponsored by AIAA.

(NASA-TM-X-73424 E-8762) Avail NTIS HC \$3.50 CSCL 01A

The approach and takeoff performance was evaluated of a contracting cowl variable geometry design inlet installed on a high-bypass-ratio turbofan engine. The design was finalized after consideration of aerodynamic, acoustic, and mechanical factors which would lead to a viable flight-worthy concept. The aerodynamic results are presented in terms of inlet recovery and distortion parameter as functions of throat Mach number, and acoustic results in terms of Perceived Noise Level. The contracting cowl high throat Mach number inlet is shown to be an attractive means to reduce forward radiated noise from a high bypass ratio turbofan engine. Author

**N76-27169\*#** National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

**WING SHIELDING OF HIGH VELOCITY JET AND SHOCK-ASSOCIATED NOISE WITH COLD AND HOT FLOW JETS**

U VonGlahn, D Groesbeck, and J Wagner 1976 22 p refs. Presented at 3d Aero-Acoustics Conf, Palo Alto Calif, 20-23 Jul 1976, sponsored by AIAA.

(NASA-TM-X-73428 E-8771) Avail NTIS HC \$3.50 CSCL 01A

Jet exhaust noise shielding data are presented for cold and hot flows (ambient to 1,100 K) and pressure ratios from 1.7 to 2.75. A nominal 9.5 cm diameter conical nozzle was used with simple shielding surfaces that were varied in length from 28.8 to 114.3 cm. The nozzle was located 8.8 cm above the surfaces. The acoustic data with the various shielding lengths are compared to each other and to that for the nozzle alone. In general, short shielding surfaces that provided shielding for subsonic jets did not provide as much shielding for jets with shock noise; however, long shielding surfaces did shield shock noise effectively. Author

**N76-27170\*#** National Aeronautics and Space Administration Ames Research Center Moffett Field Calif

**WIND TUNNEL INVESTIGATION OF A LARGE-SCALE MODEL OF A LIFT/CRUISE FAN V/STOL AIRCRAFT**

Bruno J Gambucci, Kiyoski Aoyagi, and L Stewart Rolls May 1976 109 p refs

(NASA-TM-X-73139 A-6619) Avail NTIS HC \$5.50 CSCL 01A

An investigation was conducted in the Ames 40 by 80 Foot wind tunnel to determine the aerodynamic characteristics of a large scale model of a lift/cruise fan V/STOL aircraft. The model was equipped with three fans, one mounted in the forward section of the fuselage in a lift mode and two mounted on top of the wing adjacent to the fuselage in a lift/cruise mode. The

data that were obtained include longitudinal and lateral-directional characteristics of the model with the horizontal tail on and off for both the Powered lift and cruise configurations Powered lift data were obtained at several wind tunnel velocities and at several lift/cruise fan thrust vector angles by varying the position of the hooded deflectors from 0 deg (the cruise condition) to 90 deg  
Author

**N76-27171\*#** Scientific Translation Service Santa Barbara Calif  
**PRACTICAL AERODYNAMICS OF THE YAK-40 AIRCRAFT**  
L Ye Bogoslavskiy Washington NASA Jun 1976 225 p  
Transl into ENGLISH of the book Prakticheskaya Aerodinamika  
Samoleta Yak-40 Moscow Transport Press 1975 p 1-153  
Revised  
(Contract NASw-2791)  
(NASA-TT-F-17010) Avail NTIS HC \$7.75 CSCL 01A

The structural and aerodynamic properties of the Yak-40 passenger aircraft and its technical flight characteristics are presented The problems of flying techniques are discussed and specific recommendations are given for executing flight under various conditions Information is presented about the equilibrium stability and controllability flight in specific situations flying the aircraft with engine cutout and in turbulent air Some propositions are also given from the theory of flight which simplify the study of the problems of practical aerodynamics and flight operation  
Author

**N76-27172#** Weapons Research Establishment Salisbury (Australia)

**STORE SEPARATION FROM AIRCRAFT USING A CAPTIVE TRAJECTORY YAWMETER SYSTEM**  
E R A Landers G J Simpson and G Bishop Oct 1975 17 p refs  
(WRE-TN-1522(WR/D)) Avail NTIS HC \$3.50

A captive trajectory yawmeter system is proposed for the simulation of external store separation from aircraft in a wind tunnel at subsonic and transonic speeds The important difference between this and other captive trajectory systems is that the store loads are derived from measurements of the flow field and not directly measured  
Author

**N76-27174\*#** Chrysler Corp New Orleans La Space Div  
**LOW SUBSONIC AERODYNAMIC CHARACTERISTICS OF FIVE IRREGULAR PLANFORM WINGS WITH SYSTEMATICALLY VARYING WING FILLET GEOMETRY TESTED IN THE NASA/AMES 12 FOOT PRESSURE TUNNEL (LA65)**  
J W Ball and D B Watson Jun 1976 294 p refs  
(Contract NAS9-13247)  
(NASA-CR-144600 DMS-DR-2246) Avail NTIS HC \$9.25 CSCL 01A

An experimental and analytical aerodynamic program to develop predesign guides for irregular planform wings (also referred to as cranked leading edge or double delta wings) is reported the benefits are linearization of subsonic lift curve slope to high angles of attack and avoidance of subsonic pitch instabilities at high lift by proper tailoring of the planform-fillet-wing combination while providing the desired hypersonic trim angle and stability Because subsonic and hypersonic conditions were the two prime areas of concern in the initial application of this program to optimize shuttle orbiter landing and entry characteristics the study was designated the Subsonic/Hypersonic Irregular Planforms Study (SHIPS)  
Author

**N76-27177#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt Oberpfaffenhofen (West Germany) Inst fuer Dynamik der Flugsysteme  
**TRANSFORMATION OF RUDDER ANGLES FOR VEHICLES WITH CRUCIFORM WINGS [ZUR TRANSFORMATION VON RUDERWINKELN BEI KREUZFLUEGLERN]**  
N Sander and G Somieski 18 Mar 1975 16 p refs in GERMAN  
(DLR-IB-552-75/11) Avail NTIS HC \$3.50

Methods are described for calculating aerodynamic rudder

angles of missiles with four independently controllable cruciform rudders and cruciform wings in the same plane or rotated 45 deg The calculation of the independent angles from the autopilot command angles can only be realized by adding a secondary condition The only solution obtained by using three different calculation methods shows that the control of the independent rudders takes place following the principle of minimally induced drag corresponding to the solution realized in practice  
ESA

**N76-27178#** National Aerospace Lab Amsterdam (Netherlands)  
Div Scientific Services

**EVALUATION OF A POTENTIAL THEORETICAL MODEL OF THE WAKE BEHIND A WING VIA COMPARISON OF MEASUREMENTS AND CALCULATIONS**  
T E Labrujere and O DeVries 2 Jul 1974 50 p refs Sponsored by Neth Agency for Aerospace Programs  
(NLR-TR-74063-U) Avail NTIS HC \$4.00

The validity of the representation of the wake by discrete trailing vortices as common practice in potential theoretical calculations is considered Theoretical results obtained with a method developed at NLR are compared with experimental results obtained at NLR for a 30 deg sweptback wing The shape of the vortex sheet as well as the velocity distribution downstream from the wing are predicted reasonably well however the wake model appears to be not completely satisfactory in the wing tip region The numerical method requires improvement with respect to the description of the rolling up process of the vortex sheet  
Author (ESA)

**N76-27179#** National Aerospace Lab Amsterdam (Netherlands)  
Div Flight Dynamics

**COMPUTATIONS WITH THE GARABEDIAN AND KORN PROGRAM FOR TWO-DIMENSIONAL TRANSONIC FLOWS WITH EMBEDDED SHOCKS**  
J Smith Jul 1974 36 p refs Sponsored by Neth Agency for Aerospace Programs  
(NLR-TR-74091-U) Avail NTIS HC \$4.00

Experiences with the Garabedian and Korn program developed for the computation of compressible flows with or without shocks about given airfoil profiles and applied to compressible potential flows with or without shocks (both supercritical shockless flows and flows with shock waves) are described Its applicability in comparison with exact analytical solutions for supercritical shock-free flows obtained by means of a hodograph method and in comparison with experimental results was investigated Computations for a number of quasi-elliptical airfoils indicated that the conformal mapping procedure should be handled with care Supercritical shock-free flows could not be represented correctly Comparisons between theory and experiment for cases both with and without shocks generally showed good qualitative agreement when the suction peak levels from theory and experiment were matched (except for incidences near the design incidence) The computations break down when very strong shocks occur with shock Mach numbers of about 1.5 to 1.6 This, however is generally beyond the region of practical interest  
Author (ESA)

**N76-27181#** National Aerospace Lab Amsterdam (Netherlands)  
Div Fluid Dynamics

**TWO-DIMENSIONAL TUNNEL WALL INTERFERENCE FOR MULTI-ELEMENT AEROFOILS IN INCOMPRESSIBLE FLOW**  
O DeVries and G J L Schipholt May 1975 10 p refs  
Presented at the AGARD FDP Symp on Wind Tunnel Design and Testing Tech London 6-10 Oct 1975  
(NLR-MP-75021-U) Avail NTIS HC \$3.50

A singularity method was applied to calculated two-dimensional tunnel wall corrections for multi-element airfoils The calculations show that the well-known corrections due to Glauert can be applied for a single airfoil except for the pitching moment correction above 15 deg angle of attack but that the Glauert approach fails in the case of trailing edge flap deflections The results of the calculations agree with the strong nonlinear results previously found for a hinged flat plate at zero incidence  
Author (ESA)

**N76-27182#** National Aerospace Lab Amsterdam (Netherlands)  
Div Flight Dynamics

**ON THE MOTION OF SHOCK WAVES ON AN AIRFOIL WITH OSCILLATING FLAP**

H Tjrdeman 1 Aug 1975 10 p refs Presented at the IUTAM Symp Transsonicum II Goettingen West Ger 8-13 Sep 1975 (NLR-MP-75028-U) Avail NTIS HC \$3 50

To predict unsteady air loads on oscillating wings in transonic flow an exploratory investigation was performed on a NACA 64A 006 airfoil with an harmonically oscillating flap of 25% of the chord in two-dimensional attached transonic flow Results are presented of measurements of the periodical motion of the shock waves on this airfoil Three different types of shock wave propagation are to be distinguished the sinusoidal shock wave motion the interrupted shock wave motion and the upstream propagated shock waves An analytical model was developed with which a satisfactory explanation can be given of the observed types of shock wave motion ESA

**N76-27186#** Dundee Univ (Scotland) Dept of Mechanical Engineering

**PARAMETRIC AND NONLINEAR MODE INTERACTION BEHAVIOUR IN THE DYNAMICS OF STRUCTURES Interim Technical Report**

A D S Barr and R P Ashworth Sep 1975 26 p (Grant AF-AFOSR-2723-74 AF Proj 6813 AF Proj 9782) (AD-A020634 AFOSR-76-0003TR) Avail NTIS CSCL 01/3

The research is concerned with the investigation of the behaviour of structures under internal resonance situations in which periodic excitation of a structure in the vicinity of a natural frequency (external resonance) will excite not only that mode but others having natural frequencies related to that of the excited mode by some integral or near integral relation In this report two structural configurations are investigated These show the possibility of interaction in both two and three mode situations GRA

**N76-27187#** Lockheed-California Co Burbank  
**ABSTRACTS OF AERODYNAMICS DEPARTMENT COMPUTER PROGRAMS**

R D Elliott 22 Dec 1975 59 p Revised (AD-A020719 LR-26575-Rev-1) Avail NTIS CSCL 01/1

This report consists of one-page abstracts of active batch processor or computer graphics programs in use by the Calac Aerodynamics Department The purpose is to inform users and potential users of the availability of the programs their computing costs the status of their documentation and the responsible parties to contact in Aerodynamics and Computer Services as well as to provide brief descriptions of the programs GRA

**N76-27188#** Naval Intelligence Support Center Washington D C Translation Div  
**EXPERIMENTAL STUDY OF VERTICAL APPROACH OF A FLAT PLATE AND INCLINED APPROACH OF A WING TO THE GROUND**

Ya M Serebrinski 21 Jan 1976 18 p refs Transl into ENGLISH from Tr Tsentralnyi Aerogidrodinamicheskii Inst (USSR) no 422

(AD-A021112, NISC-Trans-3748) Avail NTIS CSCL 01/1  
A description is given of the first experiments in studying the vertical approach of a flat plate and the inclined approach of a wing to a solid surface The experiments were conducted at TsAGI The plate and the wing were submerged in water The time varying forces were measured by means of tenso-graphs incorporated in the rods of a statically determinate frame GRA

**N76-27189#** Naval Intelligence Support Center Washington D C Translation Div  
**INFLUENCE OF VISCOSITY ON PROFILE LIFT AND DRAG NEAR A SCREEN**

Ya I Voitkunsii Yu I Faddeev and N A Poleshchuk 21 Jan 1976 13 p refs Transl into ENGLISH from Tr Korablestroite-nyi Inst, Leningrad (USSR) no 65, 1969 p 43-48

(AD-A021184 NISC-Trans-3756) Avail NTIS CSCL 01/1  
A screen has a great influence on the pressure distribution

over the surface of an aerodynamic profile in comparison with profile motion in an unbounded fluid Because of this the viscous drag of a wing moving above a screen may change markedly GRA

**N76-27190#** Boeing Vertol Co Philadelphia Pa  
**VALIDATION OF ROTORCRAFT FLIGHT SIMULATION PROGRAM THROUGH CORRELATION WITH FLIGHT DATA FOR SOFT-IN-PLANE HINGELESS ROTORS Final Report, Jun 1974 - Jul 1975**

James A Staley Jan 1976 179 p refs (Contract DAAJ02-74-C-0051 DA Proj 1F2-62208-AH-90) (AD-A021176 D210-10975-1 USAAMRDL-TR-75-50) Avail NTIS CSCL 01/1

A study was conducted to evaluate the 300 000-byte version of the C-81 AGAJ74 helicopter simulation program's capability for prediction of performance rotor dynamic loads and stability for soft-in-plane hingeless rotor helicopters Available test data were compiled for the BO-105 single-rotor helicopter to provide a basis for evaluation of computer program analytical results Results indicated good correlation for trim and performance and reasonable correlation for main rotor alternating flap bending moments Poorer correlation was obtained for main rotor chord and shaft bending moments Poor agreement was obtained for response to control inputs in hover and at 100 knots this may have been due to selection of too large a numerical integration interval Approximately the same damping was indicated by test and analysis for aeroelastic stability Attempts to compare C-81 results for control power and stability derivatives with analytical results from Boeing Vertol's Y-92 computer program were not successful Significant differences were attributed to restraint of blade flapping in C-81 during these computations Author (GRA)

**N76-27191#** United Technologies Research Center East Hartford Conn

**ROTORCRAFT WAKE ANALYSIS FOR THE PREDICTION OF INDUCED VELOCITIES Final Report, Feb 1974 - Oct 1975**

Anton J Landgrebe and T Alan Egolf Jan 1976 173 p (Contract DAAJ02-74-C-0027 DA Proj 1F2-62209-AH-76) (AD-A021202 R75-911852-18 USAAMRDL-TR-75-45) Avail NTIS CSCL 01/1

A rotorcraft wake analysis for computing flow velocities induced by the rotors and wing of a helicopter is described, and predicted induced velocities are compared with experimental data from many sources Combined in a single computerized analysis are the capabilities for calculating three components of time-averaged and instantaneous induced velocities on or off the rotor(s) of single-rotor dual-rotor and winged helicopter configurations in hovering and forward flight GRA

**N76-27192#** Sikorsky Aircraft Stratford Conn  
**A METHOD FOR PREDICTING HELICOPTER HUB DRAG Final Report**

Thomas W Sheehy and David R Clark Jan 1976 110 p refs (Contract DAAJ02-74-C-0050 DA Proj 1F2-62204-AH-87) (AD-A021201 SER-50945 USAAMRDL-TR-75-48) Avail NTIS CSCL 01/1

A procedure has been developed to determine the contribution of the rotor hub to the total helicopter drag The method developed uses a three-dimensional potential flow analysis to determine the flow environment in which the hub operates combined with empirical data in order to predict the drag of the hub and its associated interference drag Predictions using the method are in good agreement with test data for unfaired and faired rotor hubs A review of available rotor hub drag test data was conducted in order to identify the factors affecting helicopter rotor hub drag The data base established was used in the development of the hub drag prediction method and also to define a systematic wind tunnel test program to refine and verify the drag prediction method and to investigate in detail the parameters affecting the drag contribution of the rotor hub GRA

**N76-27193#** Sikorsky Aircraft Stratford Conn Sikorsky Aircraft Div

# **AEROELASTIC ROTOR STABILITY ANALYSIS Final Report**

Robert A Johnston and S J Cassarino Jan 1976 201 p  
(Contract DAAJ02-74-C-0010, DA Proj 1F2-62208-AH-90)  
(AD-A020871 USAAMRDL-TR-75-40) Avail NTIS CSCL 01/3

This report describes an aeroelastic analysis that provides a complete description of the dynamics and aerodynamics of fully coupled helicopter main or tail rotor/airframe/control systems. The analysis is designed to study stability characteristics in conditions of pure axial flow or in forward flight for which it computes the system's eigenvalues and eigenvectors. For hover studies the aerodynamic derivatives include stall and compressibility effects and circulatory and noncirculatory unsteady effects are accounted for through use of Theodorsen and Loewy type lift deficiency functions. The forward-flight aerodynamic derivatives are obtained from any appropriate linear or nonlinear time history analysis. The approximations made in the forward-flight analysis limit such applications to an advance ratio of about 0.5. GRA

**N76-27200#** National Transportation Safety Board Washington D C Bureau of Aviation Safety

## **BRIEFS OF FATAL ACCIDENTS INVOLVING WEATHER AS A CAUSE/FACTOR US GENERAL AVIATION 1974**

15 Dec 1975 323 p  
(PB-250037/9 NTSB-AMM-75-16) Avail NTIS HC \$9.75 CSCL 01B

All fatal U.S. general aviation accidents involving weather as a cause/factor for the year 1974 are reported. This format presents the facts, conditions, circumstances, and probable cause(s) for each accident. Additional statistical information is tabulated on all accidents involving weather as a cause/factor by type of accident, phase of operation, injury index, aircraft damage, pilots' certificate injuries, and cause/factor(s). The publication is published annually. GRA

**N76-27201#** National Transportation Safety Board Washington D C Bureau of Aviation Safety

## **BRIEFS OF ACCIDENTS INVOLVING ROTORCRAFT, U.S. GENERAL AVIATION, 1974**

15 Dec 1975 164 p  
(PB-250038/7 NTSB-AMM-75-15) Avail NTIS HC \$6.75 CSCL 01B

U.S. general aviation rotorcraft accidents occurring in 1974 are reported. The brief format presents the facts, conditions, circumstances, and probable cause(s) for each accident. Additional statistical information is tabulated by type of accident, phase of operation, injury index, aircraft damage, pilot certificate injuries, and causal factor(s). GRA

**N76-27202#** National Transportation Safety Board Washington D C Bureau of Aviation Safety

## **LISTING OF AIRCRAFT ACCIDENTS/INCIDENTS BY MAKE AND MODEL U.S. CIVIL AVIATION 1974**

15 Dec 1975 181 p  
(PB-250039/5 NTSB-AMM-75-12) Avail NTIS HC \$7.50 CSCL 01B

All U.S. civil aviation accidents/incidents occurring in calendar year 1974, sorted by aircraft make and model, are listed. Included are the file number, aircraft registration number, date and location of the accident, aircraft make and model, and injury index for all 4,600 accidents/incidents occurring this period. GRA

**N76-27203#** National Transportation Safety Board Washington D C Bureau of Aviation Safety

## **BRIEFS OF ACCIDENTS INVOLVING CORPORATE/EXECUTIVE AIRCRAFT, U.S. GENERAL AVIATION 1974**

15 Dec 1975 57 p  
(PB-249984/6 NTSB-AMM-75-19) Avail NTIS HC \$4.50 CSCL 01B

U.S. general aviation corporate/executive aircraft accidents occurring in 1974 are reported. Included are 78 accident briefs, 15 of which involve fatal accidents. The brief format presents the facts, conditions, circumstances, and probable cause(s) for

each accident. Additional statistical information is tabulated by type of accident, phase of operation, injuries, and causal factor(s). This publication is published annually. GRA

**N76-27204#** Committee on Science and Technology (U.S. House)

## **R AND D PORTIONS OF THE AIRPORT AND AIRWAY DEVELOPMENT ACT OF 1975**

Washington GPO 1975 247 p refs. Hearings before Subcommittee on Aviation and Transportation, R and D of Committee on Science and Technology, 94th Congress, 1st Session, No. 23, 12 and 15 May 1975 (GPO-56-322). Avail. Subcommittee on Aviation and Transportation, R and D.

The FAA's fiscal year 1976 budget authorization request in the area of aeronautical research and development is considered. Coordination of research activity within the aviation industry, funding from the Aviation Trust Fund, and airport pavement research and development programs are among the topics discussed. JMS

**N76-27213\*#** National Aeronautics and Space Administration Langley Research Center Langley Station Va

## **AERODYNAMIC CHARACTERISTICS OF A POWERED TILT-PROPROROTOR WIND TUNNEL MODEL**

John C Wilson, Raymond E Mineck, and Carl E Freeman Mar 1976 273 p refs  
(NASA-TM-X-72818) Avail NTIS HC \$9.00 CSCL 01C

An investigation was conducted in the Langley V/STOL tunnel to determine the performance, stability, and control and rotor-wake interaction effects of a powered tilt-propeller aircraft model with gimbal-hub rotors. Tests were conducted at representative flight conditions for hover, helicopter transition, and airplane flight. Force and moment data were obtained for the complete model and for each of the two rotors. In addition to wind-speed variation, the angle of attack, angle of sideslip, rotor speed, rotor collective pitch, longitudinal cyclic pitch, rotor pylon angle, and configuration geometry were varied. The results, presented in graphical form, are available in tabular form to facilitate the validation of analytical methods of defining the aerodynamic characteristics of tilt-propeller configurations. Author

## **N76-27214\*#** Grumman Aerospace Corp Bethpage NY **CORRELATION STUDY OF THEORETICAL AND EXPERIMENTAL RESULTS FOR SPIN TESTS OF A 1/10 SCALE RADIO CONTROL MODEL**

William Bihle Jr Jul 1976 155 p refs

(Contract NAS1-13578)

(NASA-CR-144995) Avail NTIS HC \$6.75 CSCL 01C

A correlation study was conducted to determine the ability of current analytical spin prediction techniques to predict the flight motions of a current fighter airplane configuration during the spin entry, the developed spin, and the spin recovery motions. The airplane math model used aerodynamics measured on an exact replica of the flight test model using conventional static and forced-oscillation wind-tunnel test techniques and a recently developed rotation-balance test apparatus capable of measuring aerodynamics under steady spinning conditions. An attempt was made to predict the flight motions measured during stall/spin flight testing of an unpowered radio-controlled model designed to be a 1/10 scale dynamically-scaled model of a current fighter configuration. Comparison of the predicted and measured flight motions show that while the post-stall and spin entry motions were not well-predicted, the developed spinning motion (a steady flat spin) and the initial phases of the spin recovery motion are reasonably well predicted. Author

**N76-27215\*#** National Aeronautics and Space Administration Ames Research Center Moffett Field Calif

## **PRELIMINARY ANALYSIS OF LONG-RANGE AIRCRAFT DESIGNS FOR FUTURE HEAVY AIRLIFT MISSIONS**

Walter P Nelms Jr, Ronald Murphy (AFFDL), and Alice Barlow (Computer Sciences Corp Mountain View Calif) Jun 1976 114 p refs

(NASA-TM-X-73131) Avail NTIS HC \$5.50 CSCL 01C

A computerized design study of very large cargo aircraft for the future heavy airlift mission was conducted using the Aircraft Synthesis program (ACSYNT). The study was requested by the Air Force under an agreement whereby Ames provides computerized design support to the Air Force Flight Dynamics Laboratory. This effort is part of an overall Air Force program to study advanced technology large aircraft systems. Included in the Air Force large aircraft program are investigations of missions such as heavy airlift, airborne missile launch, battle platform command and control, and aerial tanker. The Ames studies concentrated on large cargo aircraft of conventional design with payloads from 250 000 to 350 000 lb. Range missions up to 6500 n mi and radius missions up to 3600 n mi have been considered. Takeoff and landing distances between 7 000 and 10 000 ft are important constraints on the configuration concepts. The results indicate that a configuration employing conventional technology in all disciplinary areas weighs approximately 2 million pounds to accomplish either a 6500-n mi range mission or a 3600-n mi radius mission with a 350 000-lb payload.

Author

**N76-27217#** Air Force Systems Command Wright-Patterson AFB Ohio Foreign Technology Div  
**AN AMPHIBIAN BUILT BY RUSSIAN STUDENTS**  
 W Cajtlin and W Jagniuk 22 Jan 1976 10 p refs Transl into ENGLISH from Skrzydlata Polska (Poland) v 8 no 38 8 p  
 (AD-A020349 FTD-ID(RSII-0039-76) Avail NTIS CSCL 01/3

The development of the amphibian was divided into two stages. In the first stage it was decided to construct and test the flying boat. The second stage was to detect shortcomings revealed in the trial test and to develop and build on a wheeled landing gear.

GRA

**N76-27218#** Air Force Inst of Tech Wright-Patterson AFB Ohio School of Engineering  
**DECISION MAKING WITHIN THE ADVANCED TANKER/CARGO AIRCRAFT PROGRAM MS Thesis**  
 David H MacLeod Dec 1975 88 p refs  
 (AD-A020360 GSM/SM/75D-18) Avail NTIS CSCL 01/2

The concept of air refueling has been proven to be of enormous benefit to the capability of the Air Force. Requirements for air refueling resources have been steadily increasing as a result of improving enemy defenses and changing tactics of U S Forces. The most recent added burden is the requirement to refuel strategic airlift forces if the use of enroute air fields is denied. This requirement provides the impetus for the development of the Advanced Tanker/Cargo Aircraft (ATCA). The thesis investigates the problematical environment surrounding the ATCA program.

GRA

**N76-27221#** Army Air Mobility Research and Development Lab Fort Eustis Va  
**AN ANALYTICAL INVESTIGATION OF THE EFFECTS OF INCREASED INSTALLED HORSEPOWER ON HELICOPTER AGILITY IN THE NAP-OF-THE-EARTH ENVIRONMENT**  
 Donald J Merkley Dec 1975 30 p  
 (DA Proj 1F2-62209-AH-76)  
 (AD-A020924 USAAMRDL-TN-21) Avail NTIS CSCL 01/3

This report describes an investigation of the effects of increased horsepower on the agility of a helicopter in nap-of-the-earth (NOE) maneuvers. A computer program the Maneuver Criteria Evaluation Program was used to simulate the flight of a representative scout-type helicopter the OH-58. Calculations were made for both the standard OH-58 and an OH-58 with increased installed power. The increased installed power had significant effects on the agility of the helicopter in evasive-acceleration type maneuvers.

GRA

**N76-27223#** Lockheed-Georgia Co Marietta  
**FEASIBILITY STUDY OF C-141A FUEL CONSERVATION THROUGH AFT C G OPERATIONS Final Report Jun - Dec 1975**

James R Peele Dec 1975 134 p refs  
 (Contract F33615-75-C-3155 AF Proj 1207)  
 (AD-A021079 LG75ER0121 AFFDL-TR-75-140) Avail NTIS CSCL 01/3

This report is a feasibility study of the potential fuel savings resulting from the operation of the C-141 aircraft loaded and flown in a more aft c g condition than has been practiced in past operations. The study included a survey of actual operations at Charleston and Travis Air Force Bases, a review of C-141 aircraft loading histories taken from Weight and Balance Clearance Form F data and analyses of changes in cruise drag handling qualities and flight controls fuel management sequencing and service life associated with the operation of the C-141 aircraft at the most-aft currently-authorized c g position and beyond this position. Results are presented in terms of c g operational limits and associated fuel/cost savings.

GRA

**N76-27225#** Teledyne/McCormick Selph Hollister Calif  
**DEVELOPMENT OF A BACKUP COVER FOR THE AH-1 CANOPY REMOVAL SYSTEM Final Report, 12 May - 31 Oct 1975**  
 Donald R Duffy 31 Oct 1975 36 p  
 (Contract DAAJ01-75-C-0770)  
 (AD-A021139 USAAVSCOM-TR-75-49) Avail NTIS CSCL 01/3

This development program was funded to develop and test a backup cover for the Window Cutting Assemblies of the AH-1 Canopy Removal System. The purpose of the backup cover is to extend the service life of a Window Cutting Assembly which has developed a crack in the polycarbonate retainer. The function of the backup cover (or shell) is to aid the damaged retainer in directing explosive energy and fragments from a Window Cutting Assembly outboard away from the crewmen. This report defines the design of the backup cover, the testing performed to substantiate the design and documents the successful completion of this testing. The testing included twenty-one (21) subscale tests to verify the environmental capability of the shell design and two (2) full-scale canopy removal tests of the right side of the airframe from a simulated crash attitude.

GRA

**N76-27234\*#** Georgia Inst of Tech Atlanta  
**PROPAGATION OF AIRCRAFT NOISE Final Technical Report**  
 A D Pierce and W J Hadden Jr Jul 1976 27 p refs  
 (Grant NSG-1047)  
 (NASA-CR-148321 FTR-2) Avail NTIS HC \$4 00 CSCL 20A

The major tasks undertaken were (1) analytical and laboratory experiments on the propagation of sound from sources near a flat surface of finite acoustic impedance (2) laboratory experiments dealing with the reflection of sound from finite sized plane patches and (3) the diffraction of sound by wedge and trapezoidal-shape barriers. In addition a series of measurements were made of the background noise levels for various jet flow conditions in the Anechoic Noise Facility of the Langley Research Center's Acoustic and Noise Reduction Laboratory.

Author

**N76-27235\*#** Agnew Tech-Tran Inc Woodland Hills Calif  
**THE-CFM-56 BALANCE SHEET OF 18 MONTHS OF TESTING**  
 J Morisset Washington NASA Jul 1976 9 p Transl into ENGLISH from Air et Cosmos (France) vol 13 13 Dec 1975 p 23 25  
 (Contract NASw-2789)  
 (NASA-TT-F-17072) Avail NTIS HC \$3 50 CSCL 21E

The CFM-56 bypass turbojet engine is described. The design offers advantages of high bypass ratio and an advanced core engine comprising a single stage blower and compressor. Performance data on the core-engine components with over 6000 test hours are given. Foreign body ingestion tests, aerodynamic noise tests, and crosswind and tailwind performance tests are discussed.

Author

**N76-27236\*# Kanner (Leo) Associates Redwood City Calif  
THE CFM56 TURBOJET ENGINE PROGRESS IN THE  
REDUCTION OF ENGINE NOISE**

J P Bernard and P Raffy Washington NASA Jun 1976 40 p refs Transl into ENGLISH from proceedings of the twelfth Association Aeronautique et Astronautique de France Congress International Aeronautique (Paris) 29-30 May 1975 33 p (Contract NASw-2790)

(NASA-TT-F 17109) Avail NTIS HC \$4 00 CSCL 21E

The CFM56 is a double-body dual-flow (functioning in separated flow and multiphase flow) engine with 10 tons of thrust Test facilities for examining the aerodynamic internal and engine noise characteristics of the turbojet are described A facility for determining the effectiveness of acoustic attenuation treatment on the engine is included Most of the research was carried out under the Quiet Engine Program Maximal engine noise is plotted as a function of thrust and noise spectra at landing approach takeoff and intermediate flight speeds are presented Author

**N76-27238\*# National Aeronautics and Space Administration  
Langley Research Center Langley Station Va  
HYPERSONIC RESEARCH ENGINE/  
AEROTHERMODYNAMIC INTEGRATION MODEL, EXPERIMENTAL RESULTS VOLUME 2 MACH 6 PERFORMANCE**

Earl H Andrews Jr and Ernest A Mackley Apr 1976 426 p refs Prepared in cooperation with AiRes Mfg Co 4 Vol (Contract NAS1-6666)

(NASA-TM-X-72822) Avail NTIS HC \$11 75 CSCL 21E

Computer program performance results of a Mach 6 hypersonic research engine during supersonic and subsonic combustion modes were presented The combustion mode transition was successfully performed exit surveys made and effects of altitude angle of attack and inlet spike position were determined during these tests Author

**N76-27239# Polish Academy of Sciences Warsaw  
MODEL DESIGN AND DYNAMIC ANALYSIS OF ROTORS  
(MODELOWANIE I ANALIZA DYNAMICZNA WIRNIKOW)  
Agnieszka Muszynska 11 Sep 1975 263 p refs In POLISH  
Avail NTIS HC \$9 00**

In the very general mathematical model presented geometric and kinematic as well as physical peculiarities of rotors are expressed The model is presented in matrix form Methods of realizing the synthesis of a rotor and its optimization considering selected criteria and limited data are also described The presented mathematical model of a rotor is very universal and represents the common denominator for the majority of models described and analyzed in the literature The motion of symmetric models with nonlinear characteristics and the conditions for displacing the situation of relative balance are also analyzed Author

**N76-27240\*# General Electric Co Cincinnati Ohio Dept of  
Advanced Engineering and Technology Programs**

**QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE  
(QCSEE) AERODYNAMIC CHARACTERISTICS OF 30 5  
CENTIMETER DIAMETER INLETS**

D L Paul Aug 1975 102 p refs

(Contract NAS3-18021)

(NASA-CR-134866 R75AEG494) Avail NTIS HC \$5 50 CSCL 21E

A low speed test program was conducted in a 9- by 15-foot V/STOL wind tunnel to investigate internal performance characteristics and determine key design features required for an inlet to meet the demanding operational conditions of the QCSEE application Four models each having a design average throat Mach number of 0.79 were tested over a range of incidence angle throat Mach number and freestream velocity Principal design variable was internal lip diameter ratio Stable efficient inlet performance was found to be feasible at and beyond the 50 deg incidence angle required by the QCSEE application at its 41.2 m/sec (80 knot) nominal takeoff velocity through suitably designed inlet lip and diffuser components Forebody design was found to significantly impact flow stability via nose curvature Measured inlet wall pressures were used to select a location for the inlet throat Mach number control's static pressure port

that properly balanced the conflicting demands of relative insensitivity to flow incidence and sufficiently high response to changes in engine flow demand Author

**N76-27242# Pratt and Whitney Aircraft West Palm Beach  
Fla Research and Development Center  
INTEGRATED ACCESSORY SYSTEMS FOR SMALL GAS  
TURBINE ENGINES Final Report, 1 May 1973 - 30 Jun 1975**

Bob C Miller Jan 1976 282 p refs

(Contract DAAJ02-73-C-0003 DA Proj 1F2-62209-AH-76)

(AD-A021177 PWA-FR-6983 USAAMRDL-TR-75-46) Avail NTIS CSCL 21/5

The intent of the Integrated Accessory Systems for the Small Gas Turbine Engines Program was to optimize the controls and accessory systems for the next generation of small turboshaft gas turbine engines for Army helicopter applications A 1977 development time frame was considered A primary objective of the program was to reduce vulnerability of the controls and accessory components without severely compromising other important design criteria During the Phase I conceptual design phase, analyses and preliminary designs of Control and Accessory (C and A) configurations for both front- and rear-drive engines were accomplished Phase II included preliminary design of two candidate control and accessory systems and selection of one system for detailed design A tower shaft control and accessory drive with an air turbine starter was selected and a detailed system design of all C and A components was accomplished The critical items of the C and A system were identified and test programs were recommended for Phase III Phase III included testing of the following critical items (1) fuel pump inducer (inlet suction tests) (2) high-speed oil pump (cavitation tests) (3) electronics cooling techniques (performance tests) (4) power turbine overspeed sensor (performance tests) and (5) starter overrunning clutch (endurance tests) Author (GRA)

**N76-27243# Naval Intelligence Support Center Washington  
D C Translation Div**

**MAIN DESIGN CHARACTERISTICS OF GAS TURBINE  
ENGINE GTU-20**

I A Pasenko 15 Jan 1976 15 p Transl into ENGLISH from Energomashinostroyeniye (USSR) no 5 1962 p 8-12 (AD-A021086 NISC-Trans-3743) Avail NTIS CSCL 21/5

A new kind of power engine the gas turbine engine is now in the initial stage of its development The design of the GTU-20 gas turbine engine permits the unit method of assembly and disassembly to be used The engine proper consists of the following components which are delivered assembled for installation (1) two turbocompressors with drive box starter mounted on one frame with an automatic control system oil water, fuel and electrical systems the so-called turbocompressor unit (tcu) (2) air cooler assembled (3) regenerator assembled (for regenerator model) (4) air passages and gas passage with compensators The turbocompressor unit air cooler and regenerator are able by virtue of their size and weight to be transported and installed assembled It must be noted that the GTU-20 gas turbine engine by virtue of its characteristics can be successfully used both to drive a ship propeller as well as for other installations including fixed power engineering works At present each GTU-20 engine before delivery passes through long plant tests under complete load for the purpose of a comprehensive and careful design checkout as well as a check of the engine's reliability for many hours of operation under load GRA

**N76-27244# Florida Univ., Gainesville Dept of Mechanical  
Engineering**

**OPTIMIZATION OF GOVERNOR DESIGN IN HELICOPTER  
PROPULSION SYSTEMS WITH ZERO TORSIONAL STIFF-**

**NESS COUPLINGS Final Report, Jan 1974 - Dec 1975  
John M Vance Michael G Veno and Joseph J Curran (GE)  
30 Sep 1975 75 p**

(Grant DAHC04-74-G-0089)

(AD-A020495, ARO-12095 1-RTL) Avail NTIS CSCL 01/3

The effect of a torsional isolater on governor design for helicopter turboshaft engines was investigated mathematically. It was found that the torsional isolater can significantly improve torsional stability if the power turbine governor is redesigned to take advantage of the isolater characteristics. GRA

**N76-27245#** Naval Weapons Engineering Support Activity  
Washington D C  
**ENGINE LIFE MANAGEMENT SIMULATION MODEL (ELMSIM) USER'S MODEL**

William E Clark Jr and William C Booth Sep 1975 91 p ref  
(AD-A020307 NAVWESA-R-7510) Avail NTIS CSCL 01/3  
ELMSIM was developed in 1974-1975 as an interim measure to assist in the evaluation of the number and distribution of spare aircraft engines of the U S Navy pending the development of a four maintenance echelon analytical technique NAVMET (to be published as Report R-7511) and also for use in evaluating changes in assumptions and results of NAVMET. The model simulates the removal of engines from aircraft at an operating base and their subsequent flow through the base or depot repair or overhaul process and transit pipelines. The report describes the model and includes a program listing and a description of variables. It discusses assumptions, calculations, output reports and analytical applications. Author (GRA)

**N76-27246#** National Aeronautical Establishment Ottawa (Ontario)

**A FLIGHT INVESTIGATION USING VARIABLE GLIDE PATH TRAJECTORIES TO COMPENSATE FOR WINDS AND MODERATE WIND SHEARS**

W S Hindson and R E Smith Feb 1976 62 p refs  
(LR-589 NRC-15215) Avail NTIS HC \$4 50

The influence of wind, wind shears and turbulence on the approach and landing tasks of STOL and V/STOL aircraft has become of significant concern for this evolving class of flight vehicles, particularly during instrument flight operations. Flight experiments were carried out to assess the considerations in alleviating the effects of along-track, a priori wind including moderate shears by adjusting the approach glide path for the conditions of the day. A Bell 205A helicopter modified as an airborne simulator and equipped with a modest programmable guidance and display capability was used for the tests which were carried out in the operational environment of the Rockcliffe (Ottawa) STOLport. Author

**N76-27247\*#** Decision Science Inc San Diego Calif  
**DESIGN OF AN ALL-ATTITUDE FLIGHT CONTROL SYSTEM TO EXECUTE COMMANDED BANK ANGLES AND ANGLES OF ATTACK** Technical Report, Jan 1975 - Jan 1976

George H Burgin and David M Eggleston Jan 1976 162 p, refs

(Contract NAS1-13773)  
(NASA-CR-145004) Avail NTIS HC \$6 75 CSCL 01C

A flight control system for use in air-to-air combat simulation was designed. The input to the flight control system are commanded bank angle and angle of attack; the output are commands to the control surface actuators such that the commanded values will be achieved in near minimum time and sideslip is controlled to remain small. For the longitudinal direction a conventional linear control system with gains scheduled as a function of dynamic pressure is employed. For the lateral direction a novel control system consisting of a linear portion for small bank angle errors and a bang-bang control system for large errors and error rates is employed. Author

**N76-27248\*#** Kanner (Leo) Associates Redwood City Calif  
**EXPLICIT FORM OF THE OPTIMUM CONTROL LAW FOR A RIGID AIRCRAFT FLYING-IN TURBULENT ATMOSPHERE**

G Coupry Washington NASA Jul 1976 22 p refs Transl into ENGLISH from 'Forme explicite de la loi optimale de pilotage d'un avion rigide volant en atmosphere turbulente', NATO AGARD Symp on Impact of Active Control Tech on Airplane Design Paris ONERA TP no 1412 13-18 Oct 1974 p 9-1 to 9-10

(Contract NASw-2790)

(NASA-TT-F-17094 ONERA-TP-1412) Avail NTIS HC \$3 50 CSCL 01C

Flight of military aircraft at high speeds and low altitudes makes it necessary to use ride control systems to improve comfort, handling qualities and combat ability. In designing such systems, flexibility can be omitted due to the large difference between the frequencies associated with flight mechanics and those associated with the first flexible mode. Closed loop systems which feed back some output information to the controls through appropriate filters are widely used by designers, but increase the response time of the aircraft during maneuvering which can be a source of difficulty in some missions. The open loop system described senses turbulence which is used after filtering to activate the controls. This type of system has no effect on the handling qualities of the aircraft. Author

**N76-27374#** Royal Netherlands Aircraft Factories Fokker Schiphol-Oost

**ELECTRICAL PROPERTIES OF EPOXY PREIMPREGNATED KEVLAR-49 FIBRE MATERIAL F 180 10/1581**

L M Godfried 25 Apr 1974 7 p

(FOK-R-1775) Avail NTIS HC \$3 50

The properties were determined for the application of this material instead of glass fabric reinforcement on the F28 radome. The dielectric constant and the loss tangent on a solid laminate as well as the insertion phase difference and the transmission loss on a sandwich panel were established. It was found that F 180 10/1581 Kevlar-49 is suitable as facing material for the F28 radome with regard to its electrical properties. ESA

**N76-27375#** Royal Netherlands Aircraft Factories Fokker Schiphol-Oost

**RELATION BETWEEN FLEXURAL PROPERTIES AND SPAN TO THICKNESS RATIOS OF CARBON FIBRE REINFORCED EPOXY RESIN**

L M Godfried Aug 1974 10 p

(FOK-R-1805) Avail NTIS HC \$3 50

To determine the flexural properties of carbon fiber reinforced plastics as a function of span to thickness ratios, a three point loading flexural test was carried out on a CFRP finished with epoxy resins for good compatibility. Flexural tests show that design values for flexural modulus and strength for CFRP material with fiber weight of 55 % are reached at 1 thickness ratio over 40. ESA

**N76-27400\*#** Hughes Helicopters Culver City Calif  
**DESIGN AND EVALUATION OF THIN METAL SURFACE INSULATION FOR HYPERSONIC FLIGHT**

Robert C Miller and Alexander M Petach Jun 1976 45 p, refs

(Contract NAS1-13606)

(NASA-CR-144914) Avail NTIS HC \$4 00 CSCL 11F

An all-metal insulation was studied as a thermal protection system for hypersonic vehicles. Key program goals included fabricating the insulation in thin packages which are optimized for high temperature insulation of an actively cooled aluminum structure and the use of state-of-the-art alloys. The insulation was fabricated from 300 series stainless steel in thicknesses of 0.8 to 12 mm. The outer 0.127 mm thick skin was textured to accommodate thermal expansion and oxidized to increase emittance. The thin insulating package was achieved using an insulation concept consisting of foil radiation shields spaced within the package and conical foil supports to carry loads from the skin and maintain package dimensions. Samples of the metal-insulation were tested to evaluate thermal insulation capability, rain and sand erosion resistance, high temperature oxidation resistance, applied load capability and high temperature emittance. Author

**N76-27415#** Royal Netherlands Aircraft Factories Fokker Schiphol-Oost

**CORROSION RESISTANCE OF ALUMINIUM ALLOYS AS A FUNCTION OF PRETREATMENT AND PAINT SYSTEM**



P F A Bijlmer 15 Aug 1974 55 p  
(FOK-R-1806) Avail NTIS HC \$4 50

An investigation on the effects of parameters such as material pretreatment adhesive primer paint primer and paint system on the paint adhesion both before and after exposure to a water test and on the corrosion intensity after exposure to a film form corrosion test as a function of the time of exposure was carried out to improve aircraft aluminum alloy protection against corrosion  
ESA

**N76-27416#** National Aerospace Lab Amsterdam (Netherlands)  
Div Structures and Materials

# **HIGH TEMPERATURE GAS TURBINE MATERIALS**

R J H Wanhil Jun 1975 21 p refs

(RNLA-FB-C13-KL 1975)

(NLR-TR-75098-U) Avail NTIS HC \$3 50

The requirements and problems of high temperature materials in gas turbines are reviewed with specific reference to turbine disks blades vanes and combustion cans The mechanical and environmental property requirements of these components are discussed followed by an overview of the types of materials used The problems of creep and stress rupture low cycle fatigue (including thermal fatigue) oxidation and hot corrosion are summarized  
Author (ESA)

**N76-27431#** Royal Netherlands Aircraft Factories Fokker  
Schiphol-Oost

# **LONG-TERM ARTIFICIAL AGEING TESTS ON STRUCTURAL ADHESIVE REDUX 775 LIQUID POWDER**

J Koetsier 16 Dec 1975 24 p

(FOK-R-1796) Avail NTIS HC \$3 50

Results are given of artificial aging tests on adhesive REDUX 775 liquid and powder to investigate the durability of the bonded joints under various environmental conditions Overlap shear test specimens sawn from exposure test panels, were tested at room temperature after 200 500, 750 and 1 000 hrs aging at 70 C 95 - 100 % relative humidity 30 days aging at 50 C 95 - 100% relative humidity 200 500 1 000 and 3 000 hrs immersion in boiling tap water (95 - 100 C) Test results show that the durability of REDUX 775 liquid and powder bonded joints is slightly/not affected by the long-term exposure to the hot-wet environmental test conditions (the 4 500 hrs exposure excluded)  
Author (ESA)

**N76-27441#** Exxon Research and Engineering Co Linden NJ  
Government Research Lab

# **DEVELOPMENT OF HIGH STABILITY FUEL Final Report, 1 Apr - 30 Nov 1975**

William F Taylor and John W Frankenfeld Dec 1975 147 p refs

(Contract N00140-74-C-0618)

(AD-A020383 EXXON/GRU 15GAHF 75) Avail NTIS CSCL 21/4

The program to develop High Stability JP-5 is framed in the context of an extended effort involving bench scale studies of the fuel modifications necessary to improve the thermal stability of JP-5 type fuels so that fuel production specifications and storage and handling techniques can be established Fuel modifications to be experimentally investigated include removal and exclusion of molecular oxygen (O2) control of trace levels of organic sulfur nitrogen and oxygen compounds control of olefin compound type and level reduction of dissolved metals control of metal surface type contacting the fuel and the use of additives This report deals with the continuation of this program  
GRA

**N76-27442#** Army Mobility Equipment Research and Development Center Fort Belvoir Va

# **ANALYSIS OF CHITIN IN CONTAMINATED FUELS Final Report, Dec 1973 - Jul 1975**

Gertrud Ernst Dario A Emeric and Sidney Levine Sep 1975 19 p refs

(AD-A020298 USAMERDC-2158) Avail NTIS CSCL 21/4

A test method is described for indicating an early stage of biodegradation (fouling) of hydrocarbon fuels by fungi and for

chemically differentiating a massive fungus contamination from a nonbiological one The test results may be used to differentiate between corrosion caused by fungi and from other origins The test method is based on the chemical analysis of chitin a polymer of N acetylglucosamine which is a cell wall constituent of most fungi  
Author (GRA)

**N76-27443#** Air Force Systems Command Wright-Patterson AFB Ohio Foreign Technology Div

# **CLASSIFICATION OF IMPURITIES**

Jan Krotky 16 Jan 1976 16 p Transl into ENGLISH from Zpravodaj Vzlu (Czechoslovakia) no 4 1973 p 33-38

(AD-A020284 FTD-ID(RS)I-2286-75) Avail NTIS CSCL 21/4

The purpose of this article was to present general information about the problems of aircraft fuel purity particularly aircraft paraffins Fuel purity requirements and filtering technology and the construction of fuel systems are discussed The increasing consumption of aircraft fuel increased quantities of fuel pumped in filling maneuvers increasing requirements of safety and the prolonged operating periods of aircraft lead to higher requirements for fuel purity  
GRA

**N76-27451#** Grumman Aerospace Corp Bethpage NY  
Research Dept

# **THE EFFECT OF BLURRING ON AIRCRAFT CLASSIFICATION BY THE MOMENT METHOD**

J Mendelsohn G Gardner and M Wohlers Jun 1976 31 p refs

(RM-620) Avail NTIS HC \$4 00

The Television Sighting Unit (TVSU) is a system for the tracking of threats by combat aircraft which combines search radar with a telescope mounted on the aircraft The radar acquires the target and locks the telescope onto it At that point the target can be tracked optically The image acquired via the telescope is then displayed on a TV screen for identification An optical device capable of acquiring images at very long ranges (75-100 miles) can be visualized An on-board microprocessor would perform various image enhancement and classification algorithms on the images and ultimately provide a judgement as to the nature of the threat The computer itself could even decide and execute the appropriate action to be taken The ability to classify identify optical images of airplanes by computer is crucial to the above scenario An approach to the problem the moment method is being investigated  
Author

**N76-27597** Engineering Sciences Data Unit London (England)  
**DRAG OF TWO-DIMENSIONAL STEPS AND RIDGES IMMERSED IN A TURBULENT BOUNDARY LAYER FOR MACH NUMBERS UP TO 3**

Nov 1975 24 p Supersedes ESDU-73028

(ESDU-75031 ISBN-0-85679-135-0) For information on availability of series sub-series and other individual data items write NTIS Attn ESDU Springfield Va 22161 HC \$242 50

Charts given in this item were derived from experimental data for excrescences transverse to the stream in a turbulent boundary layer on a flat wall (corresponding to a flat plate at zero incidence) covering the Mach number range up to 3 they apply to airflow with zero heat transfer and zero pressure gradient and are considered valid for excrescences with heights up to about one tenth of the boundary-layer thickness Guidance on other aspects of applicability including the presence of streamwise pressure gradients is given Notes on the accuracy are also given  
ESDU

**N76-27598** Engineering Sciences Data Unit London (England)  
**GEOMETRICAL PROPERTIES OF CRANKED AND STRAIGHT TAPERED WING PLANFORMS**

Jan 1976 15 p Supersedes ESDU/A/W00 01 01

(ESDU 76003 ISBN-0-85679-136-0) For information on availability of series sub-series and other individual data items write NTIS Attn ESDU Springfield Va 22161 HC \$146 50

Information is presented concerning the reference lengths and reference points commonly used for cranked and uncranked wings with straight edges and chordwise or pointed tips. It is emphasized that in practical situations the aerodynamic center of a wing does not occur at the quarter-chord point of the aerodynamic mean chord. The standard mean chord of a wing is also used as a reference length to non-dimensionalize pitching moment coefficients. In practice this chord is positioned on the wing center-line so that its quarter-chord is coincident with the quarter-chord point of the aerodynamic mean chord. ESDU

**N76-27848** Royal Air Force Inst of Aviation Medicine  
Farnborough (England)  
**THE OPERATION OF HELICOPTERS FROM SMALL SHIPS**

J W Davies In AGARD 4th Advanced Operational Aviation  
Med Course May 1976 5 p

The operation of the Wasp helicopter from the decks of Tribal class and Leader class frigates of the Royal Navy is described and some of the difficulties involved in such operations including ship movement and turbulence are discussed. Author

**N76-27957\*** National Aeronautics and Space Administration  
Lewis Research Center Cleveland Ohio  
**OTW NOISE CORRELATION FOR VARIATIONS IN NOZZLE/  
WING GEOMETRY WITH 5 1 SLOT NOZZLES**  
U VonGlahn and D Groesbeck 1976 18 p refs Presented  
at the 3d Aero-Acoustic Conf Palo Alto Calif 20-23 Jul 1976  
sponsored by AIAA  
(NASA-TM-X-73425 E-8763) Avail NTIS HC \$3 50 CSCL  
20A

Acoustic data obtained from a model-scale study with 5 1 slot nozzles are analyzed and correlated in terms of apparent noise sources. Variations in nozzle geometry include roof angle and sidewall cutback. In addition geometry variations in wing size and flap deflection are included. Three dominant noise sources were evident in the data and correlated: fluctuating lift noise, trailing edge noise and a redirected jet mixing noise that included the effect of reflection of jet noise by the surface. Pertinent variables in the correlations include the shear layer thickness and peak jet flow velocity at the trailing edge. Author

**N76-28010\*** Army Aeromedical Research Lab Fort Rucker  
Ala  
**AVIATOR PERFORMANCE MEASUREMENT DURING LOW  
ALTITUDE ROTARY WING FLIGHT WITH THE AN/PVS-5  
NIGHT VISION GOGGLES Final Report**  
Michael G Sanders Kent A Kimball Thomas L Frezell and  
Mark A Hofmann Dec 1975 71 p refs  
(AD-A020631 USAARL-76-10) Avail NTIS CSCL 17/8

Aviators were required to fly a UH-1 helicopter at night with and without night vision goggles (AN/PVS-5). Three types of goggles were used: 40 deg field-of-view (FOV), 60 deg FOV, and 40 deg FOV with a 30% bifocal cut. During flight data were acquired on over twenty aircraft status and control input variables. These data for purposes of performance comparison were subjected to both univariate and multivariate analyses. The six subjects (instructor pilots) also responded to a questionnaire regarding preference, training and estimated capabilities of each type intensification system. The major findings of both the subjective and objective measures are provided. GRA

**N76-28093\*** Air Force Inst of Tech Wright-Patterson AFB  
Ohio School of Engineering  
**AIRCRAFT AIRFRAME COST ESTIMATION BY THE  
APPLICATION OF JOINT GENERALIZED LEAST SQUARES  
M S Thesis**  
Vernon Handel Nov 1975 120 p refs  
(AD-A020228 GOR/SM/75D-7) Avail NTIS CSCL 05/1  
Joint Generalized Least Squares is a statistical technique which allows for the interaction of a set of regression equations

through correlated disturbances. Aircraft airframe cost estimation may be accomplished by disaggregation into elements of cost such as material, labor, tooling and engineering. Data for various types of aircraft are used to demonstrate the effect of using Joint Generalized Least Squares in developing cost estimating relationships for the elements of airframe cost. A comparison is made to relationships developed using Ordinary Least Squares. Dependent on the number of observations, the number of relationships developed jointly and the different explanatory variables used, the variance of the relationships may be reduced by using Joint Generalized Least Squares. The Joint Generalized Least Squares technique is extended to permit revision of predictions using the joint distribution of the elements of cost. GRA

**N76-28094\*** Air Force Inst of Tech Wright-Patterson AFB  
Ohio School of Engineering  
**MICROECONOMIC THEORY APPLIED TO PARAMETRIC  
COST ESTIMATION OF AIRCRAFT AIRFRAMES  
M S Thesis**

William E Dunne Dec 1975 86 p refs  
(AD-A020210 GOR/SM/75D-3) Avail NTIS CSCL 05/1

The theories of microeconomics and optimal control were used to formulate a parametric cost estimation model that provides an insight into the cost flow of an aircraft airframe production program. The model developed uses original total airframe quantity ('volume') and initial total production contract time as well as the traditional values of cumulative quantity, AMPR weight and speed as explanatory variables. A form of the model was solved by both a constrained least squares approach and by a nonlinear algorithm with similar results. In the analysis of the model, the parameters of volume and time were not found to be statistically significant. The surrogate variables of actual contract volume and time do not explain a significant amount of the total program cost. Several reasons are offered in the thesis. Validation of the model indicates that it is a highly satisfactory estimator of total program cost. GRA

**N76-28095\*** Air Force Inst of Tech Wright-Patterson AFB  
Ohio School of Engineering  
**A COMPUTER SIMULATION OF MAINTENANCE MAN-  
POWER REQUIREMENTS FOR THE DC-130H, VOLUME 1  
M S Thesis**

Gerald A Yates and Richard Fritz Oct 1975 145 p refs  
(AD-A020229 GOR/SM/75D-5) Avail NTIS CSCL 05/9

This thesis develops a simulation program using the Logistics Composite (L COM) Model to represent the maintenance environment and associated manpower required to support the DC-130H aircraft. Data sources for this project included the TAC MET Study of DC-130 maintenance facilities, maintenance data collection tapes from Dyess, Langley, Little Rock and Pope Air Force Bases, Technical orders and conversations with experienced maintenance personnel. The program is designed around a typical maintenance organization which provides scheduled maintenance, unscheduled maintenance and phase inspections in support of a basic flying operation. GRA

**N76-28104\*** Army Aviation Systems Command St Louis Mo  
**HISTORICAL INFLATION PROGRAM Final Report**  
Ralph W Lilge Jan 1976 37 p refs  
(AD-A020669 USAAVSCOM-TR-76-1) Avail NTIS CSCL  
05/3

This report extends, revises and summarizes previous efforts to develop the necessary rationale and methodology necessary to construct historical inflation indices relative to Army aircraft. In addition, a computerized Historical Inflation Program is presented and described. The program can be updated monthly, is easily revised for changes in Bureau of Labor Statistics methods and capable of handling data through the transition year FY 77. Output is expressed as monthly, quarterly, calendar year inflation indices (in Calendar Year 1967 base) and inflation factors (in any Fiscal Year base). These indices and factors provide a means of accurately adjusting historical cost data to constant year dollars. Author (GRA)

**N76-28107#** Rhode Island Univ Kingston Law of the Sea  
Inst

**CONTEMPORARY LAW OF THE SEA TRANSPORTATION,  
COMMUNICATION AND FLIGHT**

William T Burke Nov 1975 44 p refs Prepared in cooperation  
with Washington Univ Seattle

(Grants NOAA-04-5-158-48 NOAA-04-3-158-3)

(PB-249924/2 NOAA-76012712 Paper-28) Avail NTIS  
HC \$4 00 CSCL 05D

Contemporary international law of the sea pertaining to the  
movement of vessels and aircraft on over and under the oceans  
is examined Special attention is devoted to the recent law of  
the sea (LOS) negotiations and proposals After initial broad  
description of basic claims and fundamental policies discussion  
centers upon the major categories of claim and counterclaim  
the more detailed policy considerations involved and the trends  
in decision respecting each category of claim, including description  
of major LOS proposals and the Single Text Trends are assessed  
in terms of suggested policies and recommendations are  
offered

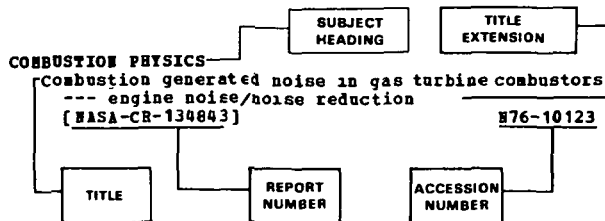
GRA

# SUBJECT INDEX

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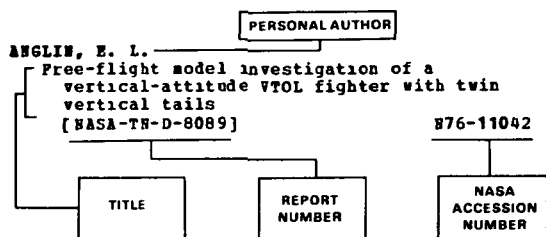


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